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Macdonald College, Ontario Agricultural College, Manitoba Agricultural College,
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Provincial Departments of Agriculture in Nova Scotia, New
Brunswick, Ontario, Saskatchewan and Alberta.*

ERRATA

Page 46, Figure 2 upside down.

Page 93, Line 41, sentence beginning "Due to the change in the world level", etc., should read "Due to the change in the world level of all prices beef cattle prices at the bottom of the swing of the present cycle will probably reach the level of 1924". The sentence following should read, "Due to the restricted demand hogs reached the peak of the cycle somewhat sooner than the writer anticipated".

Page 422, Plates 1 and 2 omitted. These appear on page 487, April, 1931, issue.

Pages 412, 413, Substitute for last three lines on page 412 and first three lines on page 413, the following: "cent, and in twenty years only 99.98 per cent. Thus at the end of twenty years the chances of any particular individual being almost fully homozygous would be very large, and a line commenced from such an individual would, of course, be highly *homogeneous* as well as highly homozygous, that is to say it would have a high degree of purity. By "highly homogeneous" I mean having a very close genetical similarity between plants. There is no test known by which one could determine exactly how homozygous and homogeneous (i.e. pure) a given line is. Theoretically it is quite possible that any given line might be much less *pure* than 99.99 per cent., which is the standard of purity used by the Canadian Seed Growers' Association for registered seed with respect to observable morphological characters of the parent plants".

Page 525, Last two lines of footnote should read "•Average height of plants—culture or filtrate plus the pathogene. °Average height of plants—culture or filtrate alone".

SCIENTIFIC AGRICULTURE

Vol. XI.

SEPTEMBER, 1930

No. 1

THE IMPORTANCE OF SOLAR RADIATION IN THE DEVELOPMENT OF GROWING PIGS

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[Received for publication June 6, 1930]

To determine if possible the effect of Solar Radiation or direct light * on young, growing pigs, an experiment was planned with light as the only variable. It has now been repeated four times, the following being a detailed account of the experiments and the results obtained.

FIRST TRIAL

Four groups of 9 pigs each were selected for the trial. Each group was made up as follows: two pigs, 4 months of age; and seven pigs 2 months of age. Pigs from 5 litters were used and distributed as evenly as possible in the 4 groups. The pigs were of Yorkshire breeding. The experiment commenced on December 23rd, 1927 and continued for a period of 126 days.

Housing

The sleeping quarters consisted of wooden buildings 9 feet x 10 feet and about 8 feet high, equipped with plank floors and straw lofts. A yard 10 feet wide and 18 feet long with walls 4 feet high was erected on the south side of each pen. Three of these yards were completely covered so that no light could penetrate into them. The fourth yard was not covered, but simply enclosed by the 4 foot fence. Feeding troughs were placed at the north end of each yard. To enable the attendant to feed the pigs in the covered pens, a drop door just above the trough was arranged so that it could be pushed inward sufficiently to allow the feed to be placed in the trough and yet not allow any light to enter.

Each pen had an opening 2 feet x 3 feet through which the pigs in each group could enter their respective yards. These outlets remained open during the entire trial so that all pigs had the same opportunity for exercise. All pens were kept clean and well bedded with straw, the attendant entering and cleaning pens through doors in the north wall.

The lighting of the pens was arranged as follows:

Pen No. 1 (With open yard) had no glass in it.

Pen No. 2 (With covered yard) had 8 square feet of ordinary window glass placed at such a height in the south wall as to flood the whole interior of the pen with light.

†Professor of Animal Husbandry.

*Direct light in this experiment refers to sunlight or skylight received by the animals without first being modified by transmission through glass or other absorbing medium.

Pen No. 3 (With covered yard) had 8 square feet of Vita glass (a) placed in south wall in similar position as window in Pen 1.

Pen No. 4 (With covered yard) had no glass in it and was totally dark at all times.

Feeds

All groups were fed exactly alike, the following feeds being used: oats, recleaned wheat screenings and wheat middlings. All grain was ground and hand fed dry twice daily with buttermilk as a protein supplement. Each group had access to a mineral mixture containing salt, lime, sulphur and charcoal.

Table 1 shows average gains made by all groups during period of 126 days. The two older pigs in each group have been listed separately from the seven younger pigs.

TABLE 1. *Showing average gains made by all groups during 126 days. First Experiment.*

| Pen | Total number of pigs | Average initial weight lbs. | Average final weight lbs. | Average gain for 126 days |
|-----------------|----------------------|-----------------------------|---------------------------|---------------------------|
| 1. Open yard | 2 | 82.0 | 251.0 | 169.0 |
| 2. Window glass | 2 | 84.5 | 253.0 | 168.5 |
| 3. Vita glass | 2 | 93.0 | 254.5 | 161.5 |
| 4. Dark | 2 | 79.0 | 237.5 | 158.4 |
| 1. Open yard | 7 | 41.5 | 144.3 | 102.8 |
| 2. Window glass | 7 | 42.0 | 113.1 | 71.1 |
| 3. Vita glass | 7 | 42.1 | 123.3 | 81.2 |
| 4. Dark | 7 | 36.1 | 107.5 | 71.4 |

It will be noted from the above table that in the case of the pigs that were four months of age at the beginning of the experiment, comparatively little difference in rate of gains occurs. All of them appeared to be able to develop about equally well under their respective conditions. The gains made by these pigs, however, cannot be stressed unduly because of the limited number of animals in each group, although the results are in general agreement with those found in the second experiment. These pigs up until the time they were selected for this experiment were kept under open yard conditions and fed a well balanced ration. It would appear that a sufficient storage of Vitamin "D" had taken place before these pigs were placed on test to prevent the development of rickets during the period of the experiment. In the case of the younger pigs, however, a study of the gains made shows quite clearly that the seven pigs in Pen 1 (open yard) made decidedly better gains than those in Pens 2, 3 and 4.

Some observations made on the physical conditions of the pigs in the various groups are illustrated in the following table:

(a) The Vita glass used in this experiment was purchased from an authorized agent of the manufacturers of this product. It was also subjected to a laboratory test involving the use of the Spectrograph by which it was found to transmit the ultra violet rays down to 2600 Angstrom Units. This test was made in order to make sure that the glass used was a standard product.

TABLE 2. *Showing actual physical condition of all pigs in each group at the conclusion of the first experiment.*

| Pen | Total number of pigs | Number of Normal pigs | Slightly Affected with rickets | Number badly Affected with rickets | Number Complete Cripples | Percentage of normal pigs |
|-----------------|----------------------|-----------------------|--------------------------------|------------------------------------|--------------------------|---------------------------|
| 1. Open yard | 9 | 9 | 0 | 0 | 0 | 100% |
| 2. Window glass | 9 | 4 | 1 | 3 | 1 | 44.4% |
| 3. Vita glass | 9 | 4 | 2 | 2 | 1 died | 44.4% |
| 4. Dark | 9 | 3 | 2 | 3 | 1 | 33.33% |

It is here clearly shown that some of the pigs in Pen 2, 3 and 4 were unable to develop normally; while, in Pen 1, all the pigs appeared to be normal in every way. It might be pointed out that the two oldest pigs in each group were in every case among those considered normal at the conclusion of the experiment. Only two pigs are listed as complete cripples, but it was quite evident that, had the experiment been carried much longer, most of those affected would have been listed as such.

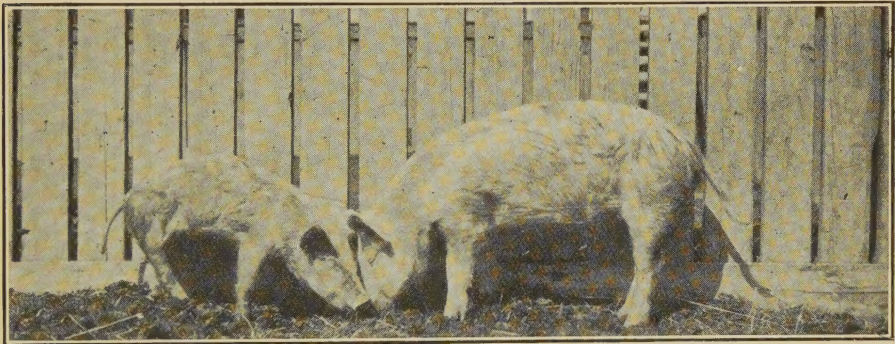


Figure 1. The pigs in this picture are litter mates. The larger one was kept in Pen 1 with access to an open yard. It is normal in every way. The smaller one was kept in Pen 4 without access to light from any source. It is a typical case of rickets. The picture was taken at the end of the first experiment.

SECOND TRIAL

So definite were the results of this trial that it was decided to repeat it the following winter. The same equipment was used. The pigs selected for the second trial were Yorkshires. Litter mates were used as far as possible and distributed evenly throughout the first three groups. The pigs selected for the fourth group and kept in the pen with the open yard were only two months of age at the commencement of the experiment, December 16, 1928. The trial had lasted for 120 days when it was decided to discontinue it on account of the very bad condition of a number of the pigs.

The following table gives a summary of the gains made by each group. No variation existed within the groups as in the previous experiment except that, in the group which was kept in Pen 4, the dark pen, one pig, somewhat older and larger than any of the others, was included.

TABLE 3. *Showing average gains made by all groups during period of 120 days. Second Experiment.*

| Pen | Total number of pigs | Average initial weight lbs. | Average final weight lbs. | Average gain for 120 days lbs. |
|-----------------|----------------------|-----------------------------|---------------------------|--------------------------------|
| 1. Open yard | 8 | 38.2 | 138.5 | 100.3 |
| 2. Window glass | 8 | 44.5 | 125.7 | 81.2 |
| 3. Vita glass | 8 | 44.25 | 118.2 | 73.95 |
| 4. Dark | 8 | 44.0 | 125.0 | 81.00 |

It is again evident as in the former trial that the pigs in Pens 2, 3 and 4 were unable to make anything like normal gains, and that the pigs in Pen 1 with open yard easily outstripped them.

The pigs were carefully examined at the conclusion of the experiment with the following result:

TABLE 4. *Showing actual physical condition of all pigs in each group at the conclusion of second experiment.*

| Pen | Total number of pigs | Number of Normal pigs | Slightly Affected with rickets | Number badly Affected with rickets | Number Complete Cripples | Percentage of normal pigs |
|-----------------|----------------------|-----------------------|--------------------------------|------------------------------------|----------------------------------------|---------------------------|
| 1. Open yard | 8 | 8 | 0 | 0 | 0 | 100% |
| 2. Window glass | 8 | 0 | 3 | 2 | 3-1 died before close of experiment | 0 |
| 3. Vita glass | 8 | 0 | 3 | 2 | 3 | 0 |
| 4. Dark | 8 | 1 | 3 | 2 | 2-both died before close of experiment | 12.5% |

It will be noted that none of the pigs in Pens 2 or 3 were normal at the conclusion of the experiment. In Pen 4, however, one normal pig was found. It was the pig referred to previously as being somewhat older than the others. This result is directly in line with the previous trial where, in every case, the older pigs were able to develop normally.

The first signs of crippling occurred in Pen 2 on March 8th. By March 25th, all showed unmistakable signs of rickets. On April 5th one died.

In Pen 3 crippling was first noticed on March 10th and by March 25th all the pigs in the group were affected.

In Pen 4, the first sign of crippling appeared on January 31st. One pig died February 26th and a second one on March 2nd. All the pigs in this group showed evidence of rickets with the exception of the one older pig which remained apparently normal.

In Pen 1, all the pigs remained normal throughout the entire duration of the experiment.

Not only were the pigs in Pen 1 normal in each experiment, but it might be added that adjacent to the experimental pens both during the winter of 1927-28 and 1928-29 some 150 pigs of the same age and weight were kept in pens similar to No. 1 with entirely satisfactory results. Not a single case of rickets was observed among this rather large number of feeder pigs, indicating very clearly that light is of vital importance in the development of the growing pig.

Related Tests

To secure further evidence that the absence of direct light was the cause of the rickets developing in the various groups, an additional test was made at the close of the first experiment. All the pigs affected were placed in a colony house in a dry lot, fed exactly the same way, but were at liberty to go in or out at will. Immediately it was noticed that all the pigs remained outside of the pen most of the time. They gradually improved until finally even the ones that at the beginning could not stand were able to walk stiffly to the trough. Eventually all recovered sufficiently to be marketed although many bent legs and enlarged joints were still in evidence.

At the end of the second trial, the covering of the yards attached to Pens 2, 3 and 4 was removed. Immediately the pigs took advantage of the

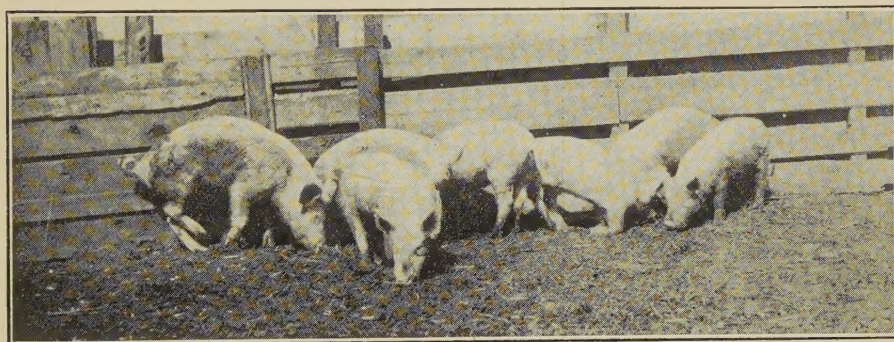


Figure 2. This picture was taken at the close of the second experiment. The pigs shown are from pens 2, 3 and 4 and all are badly affected with rickets.

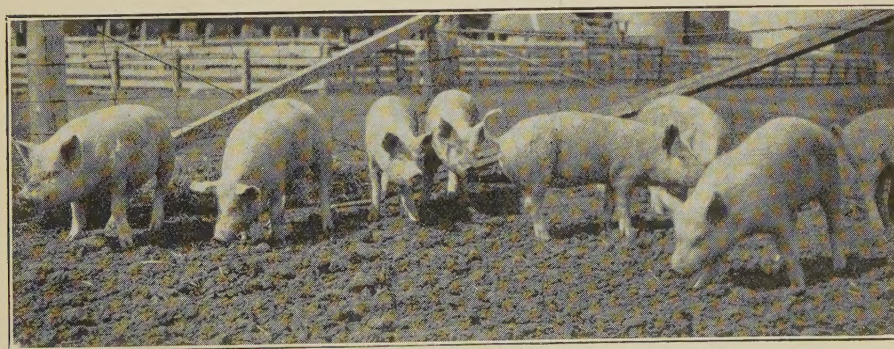


Figure 3. The same pigs as shown in Fig. 2 two months later. A marked improvement was noted very soon after they were given access to an open yard. They continued to improve gradually until they eventually reached an average weight of 200 pounds. The feeds used were exactly the same as during the duration of the experiment. The only change made was to give them free access to an open yard.

light and remained outside the pen, stretched out on their sides most of the time. The skin soon commenced to take on a ruddy hue and, in a comparatively few days, an improvement in their physical condition was noticeable.

At first, some of these pigs were unable to use their hind quarters at all, and dragged themselves about with great difficulty. Others walked on their knees while others had enlarged joints or bent legs. All of them, however, slowly recovered the use of their limbs and gradually began to thrive. Those least affected soon began to gain rapidly in weight and even some of those pigs that were listed as complete cripples at the conclusion of the experiment eventually recovered sufficiently to be marketed.

THIRD TRIAL

During the summer season of 1929, three lots of eight pigs each were placed in "A" shaped colony houses 8 feet x 8 feet square with covered yards 8 feet x 18 feet attached. In this test, the lighting of the houses was arranged as follows:

Pen 1 An opening 4 feet x 4 feet in the south wall of house covered with wire netting (no glass).

Pen 2 Windows 4 feet x 4 feet of common glass.

Pen 3 Windows 4 feet x 4 feet of Vita glass.

The experiment commenced on June 28th, 1929 and continued for 145 days. The method of feeding was similar to that used in the previous trials with the important exception that all lots were fed an abundance of fresh green alfalfa daily. The following table indicates the results obtained:

TABLE 5. *Showing average gain made by all groups during period of 145 days. Third Experiment.*

| Pen | Total number of pigs | Average initial weight lbs. | Average final weight lbs. | Average gain for 145 days lbs. |
|-----------------|----------------------|-----------------------------|---------------------------|--------------------------------|
| 1. Open window | 8 | 28.37 | 185. | 156.6 |
| 2. Window glass | 8 | 25.25 | 166.8 | 141.6 |
| 3. Vita glass | 8 | 24.9 | 163.4 | 138.5 |

No pigs in this test developed rickets, but the group in Pen 1 provided with the open window made decidedly better gains than the group in Pen 2 or Pen 3. Moreover the difference between Pen 2 (common glass) and Pen 3 (Vita glass) was negligible; in fact, was slightly in favor of the group housed behind common glass. The failure of the pigs in this experiment to develop rickets would seem to have been due to the presence of Vitamin "D" in the fresh green alfalfa.

FOURTH TRIAL

As this result was slightly at variance with our previous findings, it was decided to run still another test. This trial commenced on December 12, 1929. Two groups of eight (8) pigs of uniform breeding, age and weight were placed in each lot. A part of the equipment used in the previous experiment was utilized. Pen No. 1 was provided with light through an opening in the south wall 4 feet x 4 feet covered with wire netting and Pen No. 2 received

its light through a window of common glass of exactly the same size: viz., 4 feet x 4 feet. No Vita glass was used in this trial. The pigs were on test 130 days and, during the entire period, both groups were fed exactly alike. The results with regard to average gain appear in Table No. 6.

TABLE 6. *Showing average gains made by each group during period of 130 days. Fourth Experiment.*

| Pen | Total number of pigs | Average initial weight lbs. | Average final weight lbs. | Average gain for 130 days lbs. |
|-----------------|----------------------|-----------------------------|---------------------------|--------------------------------|
| 1. Open yard | 8 | 39.16 | 148.5 | 109.4 |
| 2. Window glass | 8 | 38.37 | 123.6 | 85.3 |

The difference in rate of gain is again very distinctly in favor of the group in Pen 1. This difference in weight, however, does not tell the whole story as will be seen by an examination of Table No. 7.

TABLE 7. *Showing actual physical condition of all pigs in each group at the conclusion of fourth experiment.*

| Pen | Total number of pigs | Number of Normal pigs | Slightly Affected with rickets | Number badly Affected with rickets | Number Complete Cripples | Percentage of normal pigs |
|-----------------|----------------------|-----------------------|--------------------------------|------------------------------------|--------------------------|---------------------------|
| 1. Open yard | 8 | 8 | 0 | 0 | 0 | 100% |
| 2. Window glass | 8 | 0 | 5 | 2 | 1 | 0% |

All pigs in Pen 2 were affected, one of them being a complete cripple, and all of the others showed unmistakable signs of rickets.

The pigs in Pen 2, by the end of the experiment, were quite definitely on the down grade, while the pigs in Pen 1 were perfectly healthy and had every indication of being in a thriving condition. Owing to the fact that this experiment was carried on during the winter months, the group in Pen 1 was exposed to a much greater extent than those in Pen 2. The temperature in Pen 1 was, at all times, practically the same as the temperature outside, on many occasions the thermometer registering as low as 30° F. below zero. In spite of this apparent handicap, these pigs remained in much better

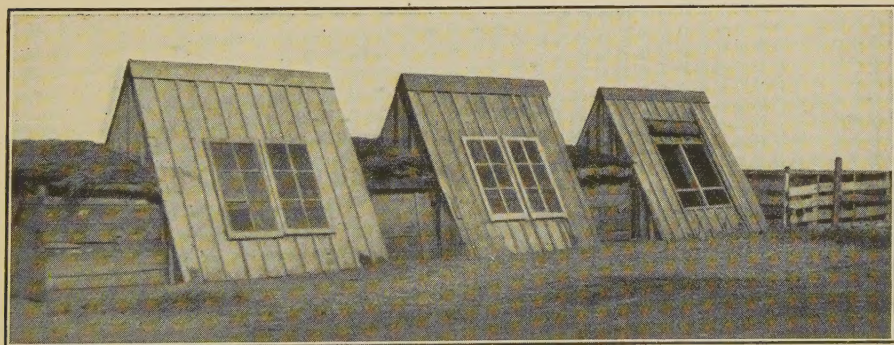


Figure 4. Southwestern exposure of the equipment used in the various experiments. On the left, Pen 3 is provided with a Vita-glass window. The window in Pen 2 (centre) is common glass while Pen 1 on right contains no glass, the opening being covered with wire netting and provided with a curtain which could be let down on particularly cold nights. All openings are of the same size to insure uniform distribution of light.

physical condition than the pigs in Pen 2, which appeared to be much more comfortable in every way.

Many experiments have been conducted in recent years on the biological effects of ultra-violet light, especially in connection with Vitamin "D" in the prevention of rickets. In the majority of these cases, rats or fowls were used; and, although the findings in several instances have some bearing upon the results obtained here, we feel that they are not quite comparable. We would be very glad to hear from anyone who has done work along similar lines using pigs and with light as the only variable.

SUMMARY

The results obtained in the foregoing experiments would seem to justify the following comment thereon:

1. That direct light is necessary for the normal development of pigs.
2. That young pigs fed what would ordinarily be called well balanced rations but deprived of light will develop rickets. *especially when in D*
3. That similar young pigs fed in the same manner but having access to open yards or direct light will remain normal.
4. That the light secured through ordinary window glass is of little value in preventing rickets in young pigs.
5. That Vita glass is of very doubtful value. Certainly if superior at all, it is not sufficiently superior to ordinary glass to justify the great difference in price.
6. That, by furnishing an abundance of fresh green legumes or probably other green plant growth, the occurrence of rickets will be prevented.
7. That young pigs show the effect of restricted light much more quickly than older ones.
8. That pigs 3 or 4 months of age that have up to that period developed normally seem to be able to withstand comparatively long periods of restricted light.
9. That access to direct light will cause rapid improvement in affected animals and eventually restore pigs showing evidence of most advanced cases of rickets sufficiently to be marketable.
10. That entirely apart from the development of rickets, the pigs which received direct light made significantly greater gains than all other groups in the experiment.
11. That, in view of the results obtained in this experiment, it would appear that the most satisfactory system of housing for young growing pigs the year round is to provide them with comfortable sleeping quarters with open yards attached to which they can have access at all times.

ACKNOWLEDGEMENTS

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THE REACTION OF WHEAT VARIETIES AT TWO STAGES OF MATURITY TO SIXTEEN PHYSIOLOGIC FORMS OF *PUCCINIA GRAMINIS TRITICI*.*

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It has been pointed out by several investigators, Aamodt (1); Hayes, Stakman and Aamodt (6); Goulden, Neatby and Welsh (3); Neatby and Goulden (8), and Goulden (2), that some varieties of wheat show a striking difference between their reactions to the stem rust organism in the seedling and mature plant stages. This was first observed in the field. It was noticed that certain varieties, while susceptible to some physiologic forms in the seedling stage, were resistant in the field, regardless of the forms present. It was evident, either that seedling resistance increased as the plants approached maturity or that another and perhaps quite different type of resistance developed. The latter possibility was indicated in the observations made by Hursh (7), on the morphology of such varieties as Kota and Acme which exhibited greater resistance in the field than in the seedling stage. More recently Hart (5) has shown that some of these varieties vary in the time of opening of the stomata. The varieties showing field resistance do not appear to open their stomata until after the morning dew has disappeared, and consequently germinating rust spores are killed before the infection hyphae have an opportunity of passing through the open stomata. This type of resistance is described as "functional resistance". Previously Goulden, Neatby and Welsh (3), Neatby and Goulden (8) and Goulden (2), had shown that mature plant resistance in H-44-24 X Marquis crosses and in a Pentad X Marquis cross was inherited in a very simple manner. This suggests a certain degree of simplicity in the nature of mature plant resistance and lends support to the theory of its functional nature. The same writers showed that mature plant resistance was inherited entirely independently of the physiological resistance observed in the seedling stage. This is a further indication of a sharp distinction between the nature of the two types of resistance.

Harrington and Smith (4) studied the seedling and mature plant reactions of four varieties, Marquis, Marquillo, Iumillo, and Vernal to three physiologic forms 17, 21, and 36. In addition to the four varieties they used a susceptible strain of Marquillo and a susceptible strain of Iumillo. A good agreement was obtained between the reactions in both stages with the exception that the susceptible strain of Iumillo seemed to be more resistant in the after heading stage. However, the material used by these writers was probably not sufficiently varied to give them a clear indication of mature plant resistance.

Since two types of resistance exist, in the breeding of rust resistant varieties, it is expedient to know the reaction of varieties used as parents in

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the two stages of development. Some varieties may possess only seedling resistance. Others may possess only mature plant resistance, and still others may possess both. A fairly complete knowledge of the behaviour of parent varieties would be of great assistance in breeding work, especially since we know that in at least two crosses the inheritance of the two types is independent. A further consideration is the relative importance of the two types of resistance from a practical standpoint. If the mature type of resistance is due to the structure, or to the functional behaviour of the plant, it seems reasonable to expect that it should apply equally to all physiologic forms since they are differentiated by their reactions on different host varieties in the seedling stage. If such is the case, the mature plant type of resistance is of great practical importance. The multiplicity of physiologic forms, and the possibility of their increase by hybridization and mutation is alarming if the plant breeder has to utilize seedling resistance only. But if mature plant resistance applies almost equally to all forms, and is fairly simple in inheritance, it is of much more practical importance from the breeding standpoint.

In order to obtain more information on some of the above points the authors outlined, in 1927, a definite project for the purpose of studying the mature plant reactions of 14 wheat varieties to at least 16 physiologic forms. This work was completed during the winter of 1928-29 and the results are reported here.

MATERIALS AND METHODS

The varieties selected for the rust resistance tests were mainly those being used in crosses in progress at the Dominion Rust Research Laboratory. The names of these varieties are, Reward, Marquis, Quality, Kota, Marquillo, Garnet, H-44-24, Hope, Vernal emmer, Acme, Pentad, Iumillo, Black Persian and Khapli. This makes a very interesting group for such a study, as it includes such varieties of *T. vulgare* as Marquis, Reward, Garnet and Quality, which are ordinarily quite severely damaged by rust, and others, such as Marquillo, Kota, H-44-24 and Hope, which are also vulgare varieties, but are highly resistant,—at least under field conditions. The other varieties all belong to the Emmer or 28 chromosome group and are nearly all highly resistant. Results of tests of the rust resistance of all of these varieties in the seedling stage have been given by Newton and Johnson (9), and Newton, Johnson and Brown (10); and these are the results which have been utilized in the present study for comparison with the mature plant reactions.

The plants studied for mature plant reactions were grown in a cool section of the greenhouse until the heads protruded about four or five inches beyond the uppermost sheath. It was found, that if inoculations were made at a more advanced stage infections were less successful. Three different methods of inoculation were tried, but only one found satisfactory. By the first method, the plants were sprayed with a spore suspension of the forms to which they were to be tested, but as the plants did not always become uniformly rusted this method was discontinued. Inoculations by means of the ordinary flat inoculating needle were tried next, and proved to be fairly satisfactory. This method, however, had one disadvantage. A slight amount

of needle injury was liable to occur, and at the time of reading the rust reactions this injury could not be distinguished from chlorotic and necrotic areas due both to rust, and to adverse environmental conditions. A few wheat varieties, in the adult stage, tend to fleck and to develop chlorotic and necrotic areas after they have been incubated in an atmosphere of high humidity, even when no rust has been applied. The method, therefore, which was finally adopted and one which gave fairly uniform results, was that of inoculating the plants by means of the fingers. The bloom was removed from the stems and leaves of all plants by gently rubbing them with the moistened fingers. Then the inoculum was applied by the fingers to all parts of the stems and leaves. After inoculation, the plants were placed in tall incubation chambers lined with blotting paper to increase the humidity, and were left there for two days. At the end of this period they were removed from the chambers, and kept subsequently, in a section of the greenhouse which was maintained at a temperature of about 70°F. during the daytime. About three weeks were necessary for complete rust development. In most varieties, the infection became progressively heavier until the plants began to ripen, and the rust passed into the telial stage. Consequently, it was found most satisfactory to read the reactions at a definite time after removal from the incubation chambers. Duplicate tests were made of each variety, each test being made with one pot of three to five plants.

The reading of mature plant reactions was a very difficult task, owing to the extreme variation in resistance on different plants. There was also great variation in the reaction types exhibited by different varieties. A variety such as Khapli will often show a large number of very small pustules, while another, such as Hope, will show a much smaller number of relatively large pustules. To obtain a complete record, the plant was divided into four regions, upper and lower culms, and upper and lower leaves. The lower part of the plant consisted arbitrarily of about the lower one third. Readings were taken first on the basis of pustule size on the four regions of the plant. The notation 0, (;), 1—, 1, 1+, 2—, 2, 2+, 3—, 3, 3+, 4—, 4, 4+, which corresponds with that used for reading seedling reactions, was used to indicate pustule size. Much less attention was paid to chlorosis and necrosis when marking adult plants than when marking seedling plants, as it was observed that on the leaves of mature plants chlorosis was quite definite even on susceptible plants, and very often definite on the leaf sheaths also. It was felt that this did not indicate resistance in the same sense as it does in the seedling stage, and that the best procedure would be to consider size of pustules chiefly. In addition to the readings of pustule size on the different regions of the plant, notes were taken on the percentage of infection on the whole plant. This was found to be very useful, as it served to differentiate between varieties which were quite susceptible, and those which showed uniformly a small number of quite large pustules.

A small specimen of the greenhouse record sheet, shown in table 1 will indicate how the notes on pustule size were taken. In addition to this, a margin on the sheet was left for notes and comments. It will be noted

that to form 15, the pustule size, on the upper leaves of Vernal, was recorded as (3 4). This means that the pustules ranged in size from 3 to 4 with type 3 predominant.

TABLE 1. Specimen of greenhouse record sheet showing method of recording mature plant reactions.

| Variety-Vernal | | | | |
|----------------|--------------------------|---------------------------|--------------------------|---------------------------|
| Pot 1 | | | Pot II-Duplicate | |
| Form | Leaves | Culms | Leaves | Culms |
| 38 | Upper (;) Lower (;) | Upper (1) Lower (;) | Upper (;) Lower (;) | Upper (0) Lower (1—) |
| 15 | Upper (3 4) Lower (3) | Upper (3 4) Lower (3+) | Upper (3 4) Lower (3) | Upper (3 4) Lower (3+) |

In order to summarize the data obtained, an attempt was made to give numerical values to the rust reactions. For seedling reactions this was comparatively easy. The numerical values assigned to the rust reaction classes are given in table 2.

TABLE 2. Numerical values arbitrarily assigned to rust reaction classes.

| | | | | | | | | | | | | | | | | | | | | | | | | |
|-----------------|------|----|------|----|-----|----|----|----|-----|----|----|----|-----|----|----|-----|----|----|----|----|----|----|----|----|
| Rust reaction | 0 0; | 1— | 1 1+ | 1± | 1++ | 2— | 2± | 2+ | 2++ | 3— | 3± | 3+ | 3++ | 4— | 4± | 4++ | | | | | | | | |
| Numerical value | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 | 13 | 14 | 15 | 16 | 17 | 18 | 19 | 20 | 21 | 22 | 23 | 24 |

In addition to these classes some of the varieties show the so-called X reactions in the seedling stage. Since an X-reaction fluctuates from the resistant to the susceptible class, it has been given the arbitrary value of 2++ to 3, that is X— = 13, X = 14, X+ = 15, X++ = 16.

It will be obvious from an inspection of table 1 that it was somewhat more difficult to assign numerical values to mature plant reactions. A somewhat similar system, however, was employed with the exception that averages were computed, based on the range in pustule size. Thus in table 1 the reaction of Vernal emmer varies from 0; to 1— but since 0; = 2, and 1— = 4, the average reading is the average of 2 and 4 = 3. To form 15 it will be noted that pustule size ranges from 3 to 4 with the 3 pustule type predominating in every case. In general the predominating type of pustule was taken as a measure of the rust reaction as in most cases the second type of pustule was comparatively rare. In cases where most of the readings were 3 to 4 the range would be taken as 3 to 3+. Therefore for Vernal to form 15 the range would be taken either as 3 to 3+ or 3 to 3++ giving an average reading of 18 or 18.5. This method appeared to give quite consistent results, and, when a number of the estimates were repeated, values within ½ or 1 point of the original values were obtained.

The system outlined above, was followed in the preparation of table 3. This table shows the numerical values for the reactions of all the varieties to 16 forms. Percentages are also recorded in this table. In our notation for percentages, 1% represents the amount of rust which is ordinarily indicated by a "trace".

TABLE 3. Seedling reactions, mature plant reactions and percentages of rust obtained in tests of 14 varieties of wheat to 16 physiologic forms.

| Variety | 9 | 14 | 15 | 17 | 19 | 21 | 32 | 33 | 34 | 36 | 38 | 48 | 49 | 50 | 52 | 53 | Average |
|--------------|------|-----|-----|------|-----|-----|------|-----|-----|------|------|------|------|----|-----|-----|---------|
| Garnet | 22 | 22 | 23 | 23 | 23 | 23 | 17 | 23 | 23 | 23 | 23 | 23 | 23 | 24 | 23 | 23 | 22.69 |
| Mat. react. | 23 | 23 | 23 | 23 | 23 | 21 | 23 | 23 | 21 | 23 | 23 | 23 | 23 | 22 | 23 | 23 | 22.75 |
| % Rust | 87 | 60 | 80 | 80 | 80 | 80 | 40 | 80 | 80 | 80 | 80 | 80 | 85 | 65 | 75 | 65 | 74.8 |
| Seed. React. | 22 | 10 | 22 | 22 | 10 | 23 | 21 | 11 | 22 | 23 | 9 | 5 | 22 | 13 | 23 | 12 | 16.88 |
| Mat. React. | 23 | 9 | 21 | 23 | 11 | 23 | 18 | 12 | 21 | 23 | 8 | 7 | 23 | 11 | 22 | 10 | 16.45 |
| % Rust | 67 | 10 | 72 | 85 | 40 | 55 | 45 | 30 | 70 | 57 | 45 | 45 | 77 | 60 | 77 | 60 | 55.9 |
| Seed. React. | 22 | 11 | 23 | 22 | 13 | 19 | 19 | 13 | 22 | 19 | 11 | 10 | 23 | 18 | 19 | 7 | 16.94 |
| Mat. React. | 21.5 | 8 | 24 | 21.5 | 8 | 21 | 20.5 | 11 | 23 | 21.5 | 11 | 12 | 20.5 | 20 | 20 | 10 | 17.09 |
| % Rust | 87 | 70 | 85 | 85 | 25 | 80 | 70 | 20 | 80 | 80 | 32 | 20 | 72 | 70 | 80 | 20 | 61.0 |
| Seed. React. | 19 | 13 | 22 | 17 | 18 | 22 | 17 | 13 | 22 | 17 | 13 | 17 | 19 | 18 | 19 | 13 | 17.56 |
| Mat. React. | 14 | 6 | 15 | 18 | 18 | 12 | 15 | 13 | 20 | 14 | 15 | 8 | 23 | 18 | 14 | 9 | 14.50 |
| % Rust | 70 | 60 | 65 | 55 | 50 | 70 | 60 | 75 | 75 | 35 | 5 | 30 | 70 | 80 | 70 | 20 | 55.6 |
| Seed. React. | 18 | 2 | 18 | 18 | 5 | 12 | 16 | 2 | 18 | 18 | 12 | 12 | 13 | 19 | 18 | 10 | 13.19 |
| Mat. React. | 11 | 2 | 14 | 11 | 4.5 | 11 | 14 | 3 | 10 | 15 | 8 | 7 | 9 | 17 | 8 | 9 | 9.59 |
| % Rust | 40 | 1 | 55 | 30 | 1 | 25 | 40 | 1 | 10 | 40 | 10 | 5 | 30 | 30 | 10 | 12 | 21.2 |
| Seed. React. | 20 | 8 | 20 | 19 | 16 | 20 | 19 | 7 | 21 | 20 | 16 | 7 | 21 | 13 | 23 | 5 | 15.94 |
| Mat. React. | 14 | 7.5 | 14 | 15 | 14 | 20 | 15 | 7.5 | 15 | 14 | 10.5 | 6 | 14 | 14 | 17 | 4.5 | 12.62 |
| % Rust | 42 | 15 | 45 | 60 | 40 | 50 | 60 | 2.5 | 60 | 40 | 30 | 1 | 65 | 20 | 30 | 10 | 35.66 |
| Seed. React. | 18 | 11 | 18 | 18 | 7 | 18 | 16 | 5 | 18 | 5 | 13 | 18 | 5 | 5 | 7 | 13 | 12.19 |
| Mat. React. | 4 | 2 | 4.5 | 4 | 2.5 | 6 | 4 | 3 | 10 | 3 | 3.5 | 10.5 | 2.5 | 3 | 3 | 7 | 4.53 |
| % Rust | 5 | 0 | 12 | 5 | 2.5 | 5 | 1 | 1 | 10 | 1 | 1 | 10 | 5 | 1 | 5 | 1 | 4.1 |
| Seed. React. | 16 | 7 | 18 | 17 | 11 | 19 | 17 | 5 | 19 | 5 | 7 | 7 | 2 | 2 | 10 | 11 | 10.81 |
| Mat. React. | 10 | 3 | 6 | 6 | 7.5 | 4.5 | 6 | 3 | 6 | 3 | 6 | 2 | 3 | 3 | 2 | 3.5 | 4.50 |
| % Rust | 10 | 1 | 15 | 5 | 1 | 5 | 2.5 | .5 | 10 | 5 | 1 | 10 | 1 | 1 | 1 | 1 | 4.4 |
| Seed. React. | 20 | 20 | 20 | 20 | 20 | 20 | 15 | 20 | 20 | 20 | 16 | 22 | 19 | 15 | 23 | 23 | 19.56 |
| Mat. React. | 6 | 4 | 11 | 7 | 3 | 10 | 3.5 | 4 | 9 | 4 | 4.5 | 14 | 4.5 | 7 | 3 | 14 | 6.78 |
| % Rust | 5 | 1 | 1 | 5 | 1 | 22 | 1 | 1 | 5 | 5 | 5 | 15 | 1 | 5 | 1 | 5 | 4.9 |
| Seed. React. | 21 | 3 | 21 | 3 | 2 | 2 | 3 | 4 | 2 | 2 | 3 | 3 | 2 | 2 | 24 | 18 | 7.19 |
| Mat. React. | 18 | 3 | 18 | 3 | 3.5 | 3.5 | 2 | 2 | 2 | 2 | 3 | 2 | 1 | 2 | 19 | 23 | 6.69 |
| % Rust | 30 | 1 | 30 | 1 | 1 | 1 | 0 | 0 | 0 | 0 | 1 | 0 | 1 | 0 | 50 | 45 | 10.07 |
| Seed. React. | 16 | 18 | 12 | 18 | 18 | 18 | 2 | 13 | 23 | 2 | 6 | 2 | 14 | 7 | 2 | 19 | 11.88 |
| Mat. React. | 3 | 3.5 | 9 | 4 | 2 | 12 | 2 | 2 | 1 | 2 | 2 | 2 | 2 | 2 | 2 | 12 | 3.97 |
| % Rust | 5 | 1 | 5 | 1 | 1 | 25 | 1 | 0 | 0 | 0 | 1 | 0 | 0 | 1 | 1 | 7 | 3.08 |
| Seed. React. | 7 | 5 | 12 | 12 | 12 | 12 | 12 | 11 | 12 | 14 | 13 | 11 | 12 | 14 | 13 | 10 | 11.38 |
| Mat. React. | 6.5 | 3.5 | 4.5 | 7.5 | 7.5 | 8.5 | 5 | 3 | 6.5 | 3.5 | 5.5 | 3.5 | 6.5 | 6 | 7.5 | 7.5 | 5.78 |
| % Rust | 1 | 1 | 1 | 5 | 5 | 5 | 1 | 1 | 1 | 50 | 5 | 1 | 5 | 10 | 45 | 2.5 | 8.72 |
| Seed. React. | 4 | 2 | 3 | 3 | 3 | 3 | 4 | 5 | 3 | 4 | 7 | 7 | 3 | 2 | 4 | 5 | 3.88 |
| Mat. React. | 4.5 | 3 | 4.5 | 3 | 3 | 4.5 | 3 | 3.5 | 3 | 4 | 3 | 3 | 3 | 3 | 3 | 3.5 | 3.40 |
| % Rust | 60 | 30 | 70 | 35 | 45 | 60 | 10 | 40 | 50 | 35 | 5 | 40 | 30 | 10 | 17 | 35 | 38.88 |
| Seed. React. | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2.0 |
| Mat. React. | 2 | 3 | 2 | 2 | 3 | 2 | 2 | 2 | 2 | 2 | 3 | 2 | 2 | 2 | 2 | 2 | 2.19 |
| % Rust | 1 | 1 | 0 | 0 | 1 | 0 | 0 | 0 | 1 | 0 | 1 | 0 | 0 | 0 | 0 | 0 | .31 |

Figures 1 to 14 represent diagrammatically the reactions in the seedling and mature plant stages of 14 varieties to 16 physiologic forms of *P. graminis tritici*. In each figure the black dots represent seedling reactions and the circles mature plant reactions.

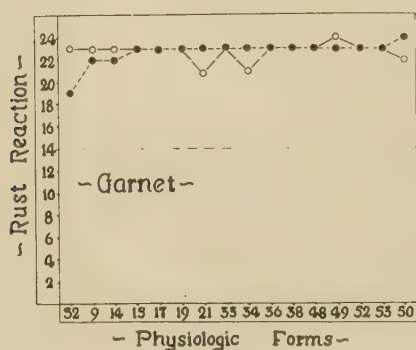


Figure 1

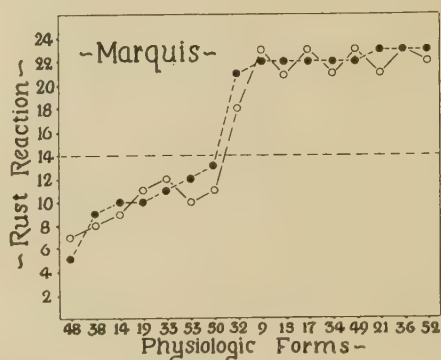


Figure 2

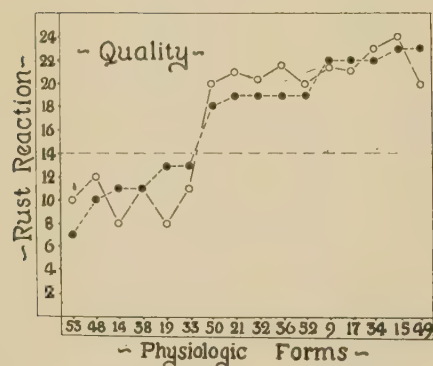


Figure 3

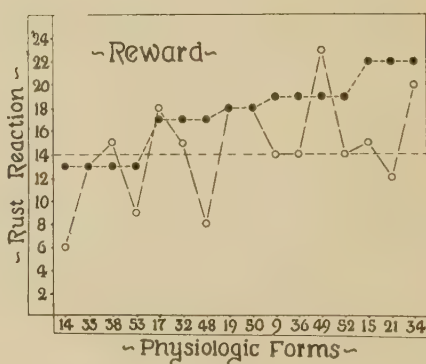


Figure 4

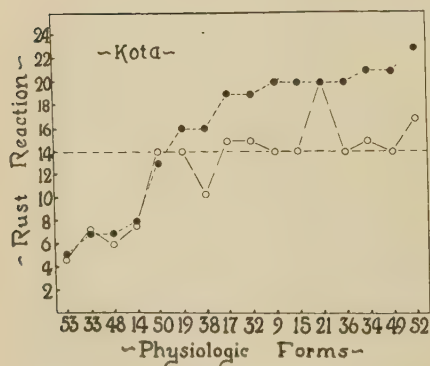


Figure 5

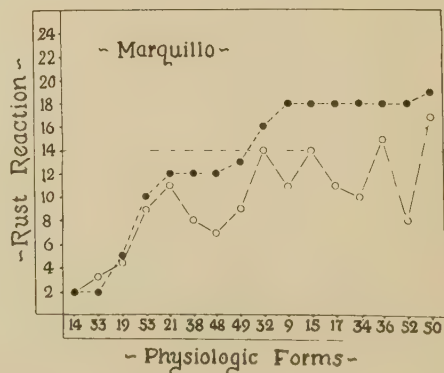


Figure 6

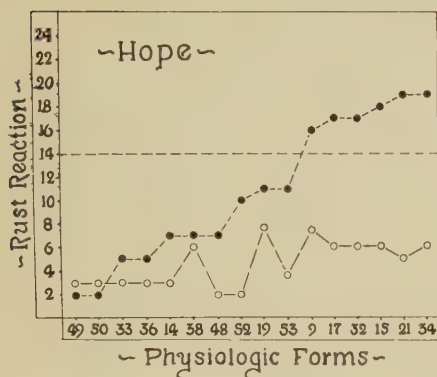


Figure 7

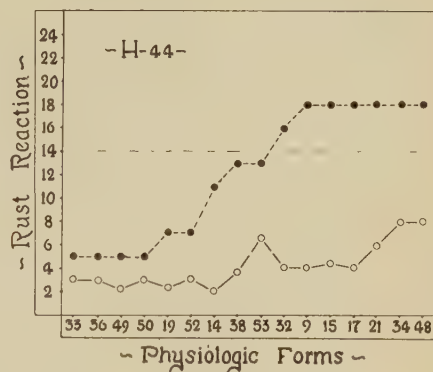


Figure 8

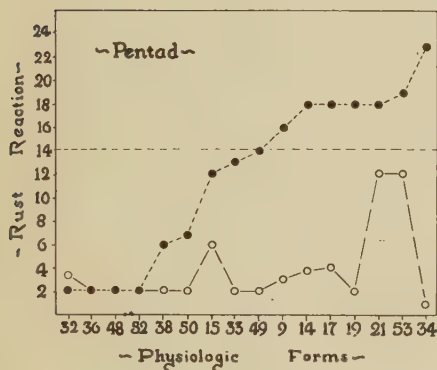


Figure 9

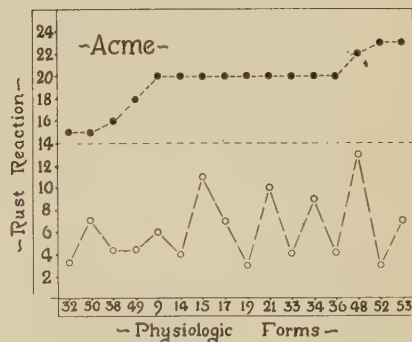


Figure 10

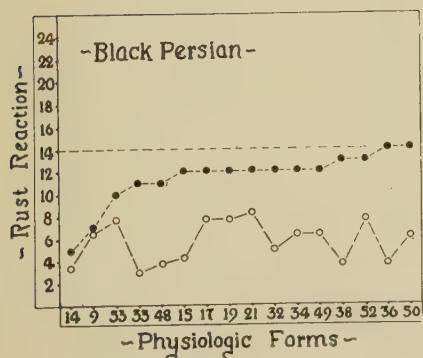


Figure 11

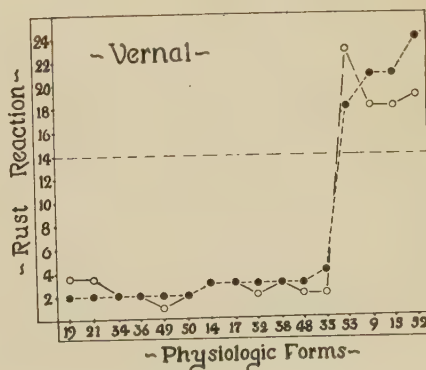


Figure 12

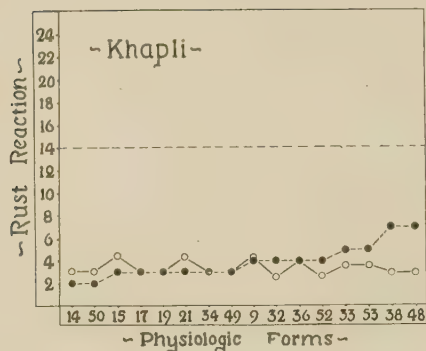


Figure 13

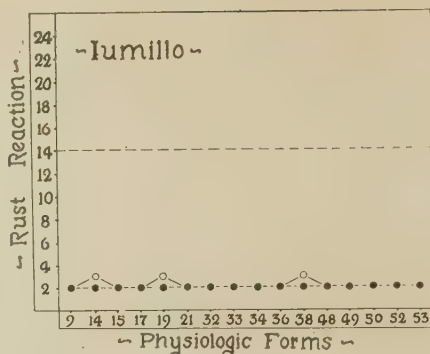


Figure 14

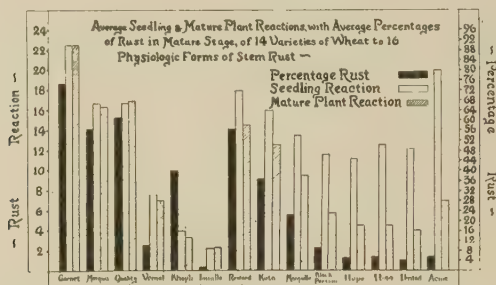


Figure 15. Average seedling and mature plant reactions with average percentages of rust on mature stage of 14 varieties of wheat to 16 physiologic forms of stem rust.

RESULTS AND ANALYSIS

VARIETAL RESISTANCE

The mature plant and seedling reactions of each variety to the 16 physiologic forms are set forth in figures 1 to 14. The black dots represent the seedling reactions of the variety to the different physiologic forms. In order to make this more obvious to the eye the physiologic forms are arranged in order according to the reaction of the variety,—those to which the variety are more resistant are placed to the left and those to which it is more susceptible are placed to the right. Thus if a variety possesses high resistance to some forms, and moderate resistance and susceptibility to others, the line joining the black dots is roughly a diagonal one across the chart. Very susceptible varieties such as Garnet show a horizontal line at the top of the chart, while very resistant varieties such as Iumillo, show a horizontal line near the base of the chart. It should be noted that the immune class is represented numerically as 1 so that none of the points can be exactly on the base line. After the charts showing seedling resistance were set up, the circular dots were put in representing mature plant resistance. The charts when complete give, therefore, a fairly clear and complete picture of the reactions of each variety in both stages of growth.

The important feature brought out by these figures was the very close agreement between seedling and mature plant resistance in some varieties, and, in others, of the almost complete lack of agreement. In those lacking agreement, the varieties were much more resistant in the mature plant stage

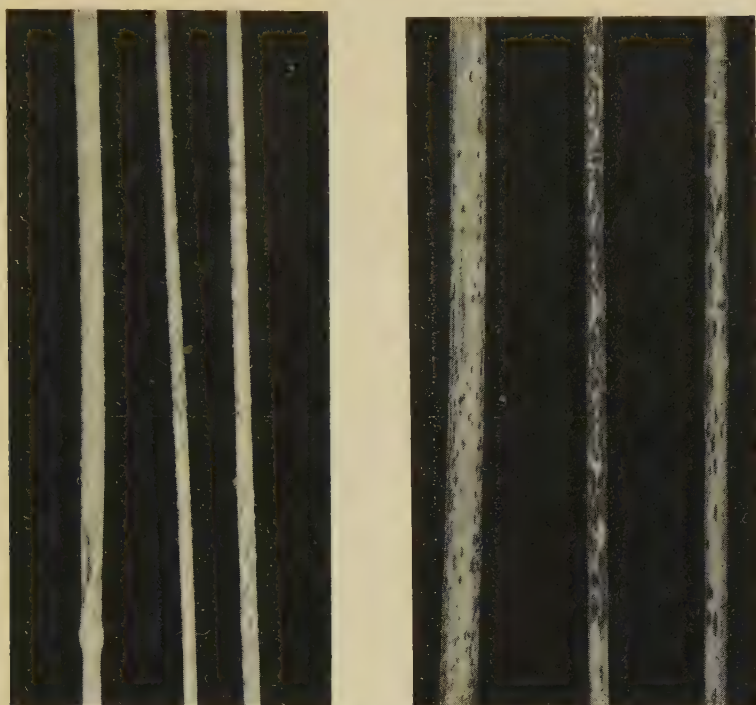


Figure 16. Reaction of stems of Quality wheat to form 38.

than in the seedling stage. On the basis of these results, it is possible to divide the varieties into fairly distinct groups. First we have the varieties that show no evidence of mature plant resistance. In this group we have Garnet, Marquis and Quality. The first of these shows no appreciable resistance to any of the forms used in either stage of growth, while Marquis and Quality show varying degrees of seedling resistance with corresponding mature plant reactions. In contrast to Garnet, Marquis, and Quality, we have such varieties as Acme, Pentad, H-44-24, and Hope that show a very decided lack of agreement between the seedling and mature plant reactions. Acme is the most striking in this respect, as while showing very little seedling resistance to any of the forms, it is resistant in the mature stage to all of them. The figures for Pentad, H-44-24, and Hope are somewhat similar, as these varieties show varying degrees of seedling resistance, and a fairly uniform degree of resistance to all forms in the mature stage.

Between the two contrasting groups, one showing mature plant resistance and the other none, are the remainder of the varieties, which are best considered individually.

Vernal emmer is highly resistant in the seedling stage to most of the forms, but it is quite susceptible to a few of them. There seems, moreover, to be a very good agreement between the reactions in the two stages. This does not agree particularly well with field observations, as Vernal emmer, in our experience, has never rusted heavily in the field, even when forms

were used in the artificially induced epidemic to which Vernal is susceptible in the seedling stage. A complication of this sort will probably not be fully explained until more is known about the exact nature of mature plant resistance in each variety, and its behaviour under different environmental conditions. There may be more than one type of mature plant resistance, and it is possible that one or other of these types is not fully expressed under greenhouse conditions. Some evidence of this seems to accrue from the results with Pentad. It will be noted from figure 9 that the mature plant reactions of Pentad to forms 21 and 53 are quite at variance with its reactions to the remainder of the forms. Obviously all of the tests could not be made under exactly similar conditions of temperature and sunlight and this may account for the quite different reactions obtained with these two forms. This seems especially likely if the Pentad resistance is of the functional or stomatal type, as temperature and sunlight may have a decided effect on the opening of the stomata.

An interesting fact concerning Vernal is brought out in table 3 by the rust percentages on the mature plants. Varieties such as Garnet and Marquis are not only susceptible to a number of forms in the seedling stage, but they also show a correspondingly high percentage of rust to these forms in the mature stage. With Vernal, however, the highest percentage is 50 per cent to form 52, and while this is very high compared with the 1 per cent and 0 per cent obtained to resistant forms, it is substantially less than that shown by Garnet or Marquis to forms to which they are susceptible in the seedling stage.

The varieties Reward, Kota, and Marquillo form a series with about the same degree of seedling resistance, and some indications of mature plant resistance. Reward shows the least mature plant resistance and Marquillo the most. In Reward the presence of mature plant resistance is, in fact, rather doubtful. In Kota and Marquillo, as indicated by their reactions, the presence of mature plant resistance is much more marked but it is not as marked as in Hope, H-44-24 and Pentad.

Black Persian shows some seedling resistance to all of the forms, but its mature plant reactions indicate considerably higher resistance. This is an indication that mature plant resistance is also present, and there is just sufficient seedling susceptibility to enable this to be detected by a comparison of the tests.

Iunillo presents a quite different appearance to Black Persian. It is resistant in the seedling stage to all of the forms used. The mature plant reactions, therefore, correspond perfectly with the seedling reactions, and, if an additional resistance appears in the mature plant stage, it cannot be detected.

Khapli gave results very similar to what would be expected from field observations. Resistance is very high in all forms in both stages. The points in the figure representing the seedling reactions correspond quite closely with those representing mature plant reactions. Khapli however gives a very typical reaction (figure 17) in that a large number of very small pustules with sharply chlorotic areas are nearly always produced. The rust



Figure 17. Reaction on leaves of mature plants of Khapli to form 15.



Figure 18. Left—reaction of mature plant leaves of Reward to form 21. Right—reaction of mature plant leaves of Reward to form 15.

percentages for the mature plant stage are, therefore, considerably higher than for such a variety as Iumillo or Black Persian. It has been pointed out above that a low percentage of rust is typical of varieties possessing mature plant resistance, regardless of the size of the pustules. In Khapli, therefore the results would indicate a lack of mature plant resistance, i.e., the resistance exhibited in the latter stage is probably exactly the same type of resistance as is shown in the seedling stage.

The results from table 3 may be summarized to some extent in the averages which are shown in the column on the extreme right. Such averages cannot be taken, however, as a complete index of the resistance of a variety. Black Persian, for example, shows about the same average seedling reaction as Pentad, but the former shows a fairly uniform reaction to all forms, while Pentad is highly resistant to some and moderately susceptible to others. The average figure seems to be the most useful for comparing seedling and mature plant reactions. In figure 15 the average results for the seedling reactions, the mature plant reactions, and the percentages of rust of each variety are put in the form of a graph. The varieties are grouped in this graph according to the magnitude of the difference between the seedling and mature plant reactions. The group on the left, from Garnet to Iumillo, show almost identical reactions in the two stages, and are arranged as a group in order of resistance, Garnet being the most susceptible and Iumillo the most resistant. The remaining group of varieties are arranged in order of the magnitude of the difference between the average reactions in the two stages. In Reward we have the smallest difference, and in Acme the greatest difference. Neglecting the percentage columns, we would classify the entire group on the right as possessing some degree of mature plant resistance. As pointed out previously, however, the evidence is not very definite in the case of Reward. It is evident from the remainder of the group that with plants showing mature plant resistance, there is a very sharp falling off in the percentage of rust. In the group from Black Persian to Hope, the percentages are very small indeed. This is in line with any theory to account for mature plant resistance from the morphological or functional standpoint, especially any type of resistance which hinders the entrance of the infection hyphae. When infection does take place the pustules developed may be fairly large but they are necessarily few in number.

If low percentages of rust indicate mature plant resistance, the varieties, Vernal and Iumillo, in the group to the left in figure 15, both possess mature plant resistance. On account of the high percentage of rust on the Khapli, it is quite out of line with the varieties on either side. The Khapli result, however, as pointed out above, is exactly what we would expect in a variety whose resistance in the later stage is identical with that in the seedling stage. In the same way, the low percentage of rust shown by Vernal and Iumillo are indications of a mature plant type of resistance, the presence of which is masked by the high degree of seedling resistance which continues throughout the life of the plant.

REGIONAL RESISTANCE

In many mature plants different reactions occur on different parts of the same plant. "Regional resistance" seems to be the most suitable term to apply to this phenomenon. The heaviest rusting on a nearly mature plant is, in general, on the regions just above the nodes and on that section of the neck or culm proper, which last emerges from the sheath of the uppermost leaf. This is illustrated in figures 16, 19 and 22. Figure 16 shows the reaction of stems of the variety Quality in the mature stage, to form 38. This variety is resistant to form 38 in the seedling stage, but in the mature stage, certain parts of the plant become very susceptible. The three stems to



Figure 19. Reaction on stems of Marquis wheat to form 50.



Figure 20. Reaction of seedling leaves of Quality wheat to form 38, left, and form 50, right.

the left show a heavy reaction just above the node, the reaction becoming progressively lighter from the node up to the base of the leaf. The smallest stem is a portion of the neck, and from the photograph, it is obvious that the infection here is again quite heavy. The three stems to the right are

slightly enlarged portions of the three on the left. They bring out more clearly the contrast between the heavy infection on the neck and the light infection on the upper part of the leaf sheath. As was stated above, in the seedling stage, Marquis gives a 2 reaction to form 38. This agrees quite well with the reaction in the mature plant stage on the leaf sheaths (figures 20 and 21) but it will be seen that a much heavier reaction can be obtained on other parts of the plant.

Figure 19 shows the reaction of Marquis to form 50. The three stems to the left again show very heavy pustules just above the nodes, the pustules gradually becoming smaller higher up on the leaf sheaths. The three stems to the right are enlarged portions of the stems on the left. Marquis in the seedling stage gives a 2- reaction to form 50 and is therefore considered resistant to this form. The reactions on the stems shown here, however, prove that very much heavier reactions can be obtained on certain portions of the mature plant than on seedling leaves.

Figure 22 illustrates the mature plant reaction of Marquis to form 53 to which it gives a $2\pm$ reaction in the seedling stage. Here, again, the seedling reaction is obtained on leaf sheaths and leaves only, as the nodes and necks show much heavier infection. In the above three cases, photographs of leaf reactions have not been shown, as the reactions on the leaves are identical with those on the upper part of the leaf sheaths. This similarity between the seedling reaction and that on the leaves of the mature plant is demonstrated in figures 20 and 21. If anything, the mature plant leaf reaction is slightly more of the resistant type than that of the seedling leaf.

The existence of a regional type of resistance, in some varieties, is extremely interesting when considered in relation to any theories that may be advanced to explain the nature of resistance. A strictly morphological type of resistance, based on the relation between the sclerenchyma and chlorenchyma bundles, would be expected to give the opposite effect to that shown here. According to the results obtained by Hursh (7) and Hart (5) we should not expect to find either morphological or functional resistance in Marquis. If the resistance is physiological we have to assume an unequal distribution in the plant of the substance or substances responsible for resistance, or an unequal influence in different portions of the plant of another factor super-imposed upon the physiological factors. The study of regional resistance is important, therefore, in that it may give some clue leading to the discovery of the exact nature of physiological rust resistance. Its main interest at the present time is in demonstrating that the reaction of a variety in the seedling stage is not necessarily a criterion of its reaction in the mature plant stage, even if there is no development of a mature plant type of resistance.

BEARING ON FUNCTIONAL RESISTANCE

It has been pointed out above that the evidence gathered on mature plant resistance supports in general the theory of functional resistance advanced by Hart (5). By genetical studies, it has been shown that mature plant resistance is inherited in a relatively simple manner, which is indirect evidence as to the simplicity of its nature. Hart (5) points out that there is

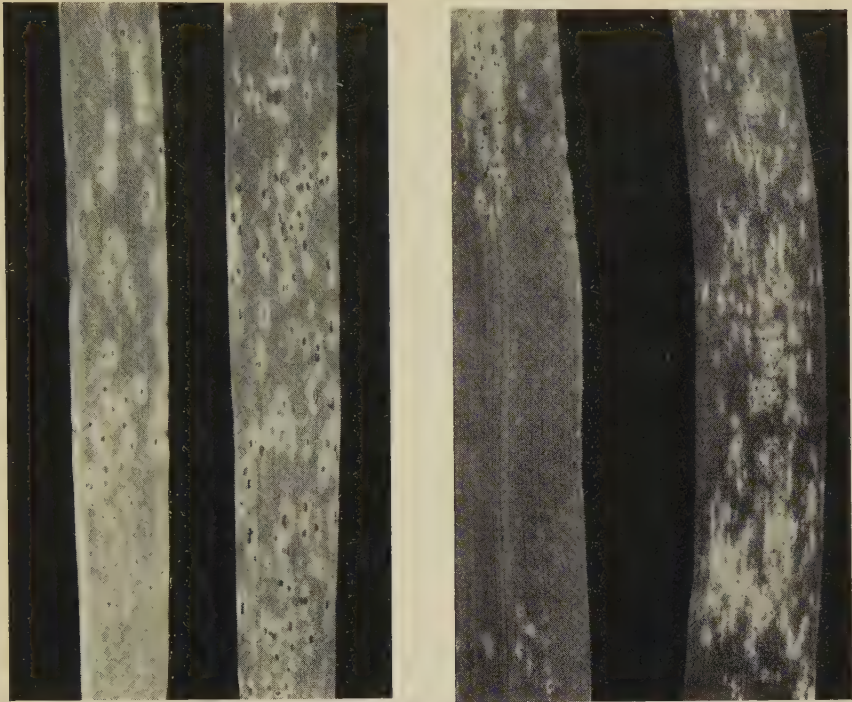


Figure 21. Reaction of mature plant leaves of Quality wheat to form 38, left, and form 50, right.



Figure 22. Reaction of stems of Marquis wheat to form 53.

no necessity for assuming the development of another type of resistance. viz., mature plant resistance, as this type may be explained on the basis of stomatal behaviour. Her assumption that a similar stomatal behaviour obtains in the seedling and mature plants seems to have been fairly well demonstrated. She has pointed out, however, that the stomata of mature plants are less sensitive than those of seedlings, and that the relative difference in sensitivity between resistant and susceptible varieties is greater in the mature plant stage than in the seedling stage. The development of such differences is, therefore, if we accept the theory of functional resistance, the development of mature plant resistance, and the two views are quite in accord.

There are, however, a few facts embodied in our results which are difficult to explain on the basis of functional resistance. In the first place, the variety Khapli, which in stomatal behaviour is very similar to Hope and Pentad, gives usually a high percentage of infections. Figure 17 illustrates the typical mature plant leaf reaction of Khapli obtained in our experiments. Similar reactions have been observed in the field. It is difficult to see how similar stomatal behaviour in Khapli, Hope, and Pentad would give such dissimilar results.

It was also noted in our experiments that a variety such as Pentad, which is susceptible to a given form in the seedling stage, would, when tested to this form in the mature plant stage, show not only a low percentage of rust, but also very small pustules. It is difficult to understand how stomatal behaviour can effect the pustule size as well as the number.

SUMMARY.

1. The purpose of this study was to obtain more complete information on the reactions of wheat varieties as seedlings, and as fully grown plants, to different physiologic forms of stem rust.

2. Fourteen varieties, varying from almost complete susceptibility to very high resistance, were tested to 16 physiologic forms for their reactions in the mature plant stage. These results were compared with the corresponding seedling reactions.

3. On the basis of the results obtained, the varieties were divided into three groups. (1) those in which there was almost perfect agreement between the seedling and mature plant reactions, (2) those in which there was a decided lack of agreement between the seedling and mature plant reactions, and (3) a group intermediate between (1) and (2) in which there was imperfect agreement.

4. In group (1) were placed Garnet, Marquis, Quality, Vernal, Khapli and Iumillo; in group (2) Hope, H-44-24, Pentad, Acme, and Black Persian; in group (3) Reward, Kota, and Marquillo.

5. Group (3) contains the varieties in which the presence of mature plant resistance is considered to be definitely established. In group (1) the varieties, Vernal and Iumillo, show close agreement in the reactions of the seedling and mature plants, but the low percentage of rust which develops on these varieties in the mature stage indicates that they too possess mature plant resistance.

6. The resistance which develops in the varieties of group (3) as they approach maturity is explained on the basis of the development of a type of resistance which is different from that observed in the seedling stage.

7. Varieties possessing mature plant resistance reacted fairly uniformly in the mature plant stage to the 16 different physiologic forms. This is an indication that plants possessing this type of resistance will, in general, be resistant to all forms, and, consequently, from the practical standpoint this resistance is of greater importance than seedling resistance.

8. All the varieties tested, especially Marquis and Quality, showed a tendency, in the mature stage, to rust more heavily in certain regions than in others, particularly above the nodes and on the culms between the uppermost leaf and the head. For this phenomenon the term "regional resistance" is suggested.

9. The results obtained are discussed in relation to theories concerning resistance, especially with that of functional resistance, believed to be due to stomatal behaviour. It is shown that, in general, the results support the theory of functional resistance, but that there are a few facts which are difficult to explain on this basis.

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A NEW SULPHUR-RESIN SPRAY

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[Received for publication July 9, 1930]

As the outcome of studies of the toxicity of solutions of resin and sulphur towards fungi, a new spray has been developed which is a compound of potassium hydroxide, flowers of sulphur and pine resin.

The discovery (1) that alkaline solutions of resin were quite toxic to hop mildew, *Pseudoperonospora humuli* (Miy. & Tak.) Wils., led us to study their toxicity towards other fungi. Although their toxicity varied greatly towards distinct species of fungi, in general, the toxicity of alkaline solutions of pine resin is sufficiently high to warrant the incorporation of solutions of resin in protective sprays against most species of fungi. Furthermore, our investigations (2) showed that solutions of resin in potassium hydroxide had a high efficiency value as a spreader and adhesive for Bordeaux, higher than all other spreaders and adhesives under test.

The two-fold effect of alkaline resin, its toxicity towards fungi and the manner in which it spreads over and adheres to foliage, led us to incorporate this solution with a potassium polysulphide (livers of sulphur) solution.

PREPARATION OF THE STOCK SPRAY MATERIAL

Initially, the stock spray was prepared by mixing equal parts of a potassium polysulphide solution (A) with a potassium resin solution (B). The former, solution A, was prepared by dissolving flowers of sulphur in a hot aqueous solution of potassium hydroxide to the point where a further addition of sulphur caused a cloudiness to appear. A standard formula of 4 lbs. sulphur, 5 lbs. potassium hydroxide, and 10 lbs. of water was adopted. The latter, solution B, was prepared by heating 4 lbs. of pine resin, 2 lbs. potassium hydroxide and 10 lbs. of water. This concentration of potassium hydroxide is sufficient to dissolve over twice the adopted amount of resin. However, any substantial increase in the resin-KOH ratio caused a resinous precipitate to be thrown out of solution when the stock spray was prepared by mixing equal quantities of solution A and B (modified), and this resinous precipitate failed to dissolve when the stock spray was diluted to spray strength.

The stock spray remains clear for a short time after mixing equal proportions of standard A and B solutions but a flocculant precipitate appears on standing. However, the precipitate so formed dissolves readily when the stock spray is diluted with cold water to spray strength. One gallon of the stock spray in fifty gallons of water was found to be the most satisfactory spray strength as a combination fungicide and contact insecticide.

Two dry powdered forms of this spray material were developed in order to reduce the manufacturing and handling costs. The initial form was prepared by fusing with heat separately a damp 4:5 mixture of sulphur and potassium hydroxide, and a damp 4:2 mixture of pine resin and potassium hydroxide, and subsequently mixing and grinding equal quantities of the solids thus obtained. The second form was prepared by fusing all the

†Plant Pathologist in charge, and Plant Disease Investigator respectively.

ingredients in the same proportions as a single mix, and this method of preparation proved to be more ideal in every respect. A standard mix was adopted consisting of 4 lbs. sulphur, 4 lbs. resin, 7 lbs. potassium hydroxide and 1 lb. water. Sufficient heat is self generated to fuse this mixture without the application of outside heat. In practice it is essential to vigorously stir the mixture while the reaction occurs to prevent charring. A granular mass is obtained which dries to a granular powder if spread out into thin layers before the fuse cools. This granular potassium polysulphide resin powder dissolves readily in cold water as a clear solution without further mechanical grinding. As a fungicide and contact insecticide, 16 lbs. of this spray powder in 100 gals. of water was found to be a satisfactory spray strength.

THE SPREAD AND ADHESIVE PROPERTIES

The sulphur-resin spray spreads evenly over foliage, adheres tenaciously and its colour is not conspicuous. These three factors are particularly advantageous in a spray for ornamentals. In Table 1 approximations are recorded of the spreading and adhesive properties of this sulphur-resin spray, and other sulphur sprays when applied to tulip leaves. The spread coefficient represents an approximation of the percentage of the leaf uniformly covered by the spray when they are dry, and the adhesive coefficient represents the percentage of the leaf uniformly covered by the spray after the same sprayed leaves are dipped in distilled water and subsequently dried. The figures reveal that the sulphur-resin spray spreads over and adheres to tulip leaves in a more satisfactory manner than Livers of Sulphur or Lime Sulphur with or without the addition of whale oil soap. Also, the addition of potassium resin to lime sulphur does not improve its spread and adhesive properties owing to the production of a resinous curd.

TABLE 1. *Approximate spread and adhesive coefficients.*

| Spray | % sulphur | % resin | Maximum 100 | |
|--------------------------------------------|-----------|---------|--------------|----------------|
| | | | Spread coef. | Adhesive coef. |
| Sulphur-resin | 0.4 | 0.4 | 100 | 95 |
| Livers of Sulphur | 0.8 | 0. | 5 | 4 |
| " " | 0.4 | 0 | 5 | 4 |
| Livers of Sulphur with 0.5% whale oil soap | 0.8 | 0 | 90 | 60 |
| " " " " | 0.4 | 0 | 90 | 60 |
| Lime-sulphur | 0.8 | 0 | 5 | 4 |
| Lime-sulphur with 0.5% whale oil soap | 0.8 | 0 | Curdled | |
| Lime-sulphur with potassium resin | 0.8 | 0.4 | Curdled | |

FUNGICIDAL PROPERTIES OF THE INGREDIENTS

The ingredients of the spray, potassium polysulphide and potassium resin are both strongly fungicidal. This was demonstrated by mixing the ingredients in various proportions with a standard agar media, inoculating with an actively growing culture of *Botrytis tulipae*, and recording the growth over a period of nine days. The data presented as Table 2, reveal that both ingredients exert a fungicidal effect and also indicate that an effective spray strength is reached when the sum of the sulphur and the resin is equal to 0.8% of the spray. This last supports the field tests conducted to determine the effective minimum concentration of the stock spray material.

TABLE 2

| Potassium polysulphide solution % | Potassium resin solution % | Sulphur % | KOH % | Resin % | 2 days cms. | 4 days cms. | 6 days cms. | 9 days cms. |
|-----------------------------------|----------------------------|-----------|-------|---------|-------------|-------------|-------------|-------------|
| 100 | 0 | 0.8 | 1.1 | — | — | — | — | — |
| | | 0.4 | 0.55 | — | — | — | 0.6 | 1.0 |
| | | 0.2 | 0.27 | — | — | 1.0 | 1.4 | 1.8 |
| 60 | 40 | 0.96 | 1.64 | 0.64 | — | — | — | — |
| | | 0.48 | 0.82 | 0.32 | — | — | — | — |
| | | 0.24 | 0.41 | 0.16 | — | 0.6 | 1.2 | 1.7 |
| | | 0.12 | 0.20 | 0.08 | — | 0.9 | 1.4 | 2.1 |
| 50 | 50 | 0.8 | 1.5 | 0.8 | — | — | — | — |
| | | 0.4 | 0.75 | 0.4 | — | — | — | — |
| | | 0.2 | 0.37 | .2 | — | — | 0.5 | 0.6 |
| | | 0.1 | 0.19 | .1 | — | 1.05 | 1.2 | 1.5 |
| 40 | 60 | 0.64 | 1.36 | 0.96 | — | — | — | — |
| | | 0.32 | 0.68 | 0.48 | — | — | — | — |
| | | 0.16 | 0.34 | 0.24 | — | — | 0.3 | 0.3 |
| | | 0.08 | 0.17 | 0.12 | — | 0.4 | 1.0 | 2.1 |
| 20 | 80 | 0.32 | 1.08 | 1.24 | — | — | — | — |
| | | .16 | .54 | .62 | — | — | — | — |
| | | .08 | .27 | .31 | — | — | 1.2 | 2.1 |
| | | .04 | .14 | .16 | — | — | 1.7 | 3.2 |
| 0 | 100 | .0 | 0.4 | 0.8 | — | — | — | — |
| | | — | 0.2 | 0.4 | — | 0.20 | 0.9 | 1.2 |
| | | — | 0.1 | 0.2 | — | 0.7 | 1.4 | 2.8 |

TOXICITY TOWARDS FOLIAGE

On tulip plants no spray injury occurred through doubling and trebling the effective concentration. As previously noted, the effective concentration was found to be 16 lbs. of the dry powdered form to 100 gals. of water. Slight spray injury occurred at greater concentration but it was not until the concentration was increased six times that conspicuous injury occurred. However, on young hop leaves, slight spray injury occurred at the effective concentration.

INSECTICIDAL PROPERTIES

In the course of our studies of the fungicidal properties of the sulphur-resin spray, we discovered that aphids, mites and red spiders were almost instantly killed if present when the foliage was sprayed. Further tests have proved that this sulphur-resin spray is an effective contact insecticide.

SUMMARY

(1) Several methods are described of preparing liquid and dry powdered stock forms of a new sulphur-resin spray material.

(2) As a spray for ornamentals, its spreading and adhesive properties and its inconspicuousness are particularly advantageous.

(3) The two components of the spray, potassium polysulphide and potassium pine resin are both fungicidal.

(4) The spray is effective as a contact insecticide.

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IMPERIAL BUREAU OF FRUIT PRODUCTION *

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Mr. Chairman and members of the Canadian Society of Technical Agriculturists, may I thank you and your Society most heartily for its invitation to this convention and for the great welcome you have all given me? I much appreciate this opportunity, of which the shortness of my visit would otherwise have robbed me, of meeting so many of the leaders of horticultural progress in Canada. I am greatly indebted also to one of your members from Vineland, who brought me here from Montreal at astonishing speed but in great comfort, so that I saw the tall ships sailing up the St. Lawrence, a fraction of the unspoiled loveliness of New Brunswick and lastly the Annapolis Valley, renowned alike for its orchards and as the cornerstone of Canadian Agriculture.

The Imperial Bureaux, with the exception of the older Bureaux of Entomology and Mycology, are the direct outcome of the Imperial Agricultural Conference of 1927. At that Conference the small band of men representing fruit production was unanimous only in wishing to set up a clearing house of information for that branch of agriculture, but were far from unanimous in their views on the proper functions of such a clearing house. Thus attention in one Dominion had hitherto been concentrated on breeding fruit varieties to suit its varying climates, in another on transportation problems, and a third on the improvement of fruit by a more careful prevention and control of orchard pests and diseases, while workers in the Crown Colonies were anxious to know how far recent findings regarding deciduous fruit growing were applicable to tropical fruits and to such crops as tea, coffee, rubber, etc. Although the resolutions of the Fruit Committee were not adopted by the Conference, its wish for the establishment of something in the nature of a Bureau was recognized.

Consequently, in April 1929, the Imperial Bureau of Fruit Production was opened at East Malling in a modest way, with R. G. Hatton director and the speaker chief officer. Two months later Miss H. McKeague became secretary and in May 1930, Mr. G. St. Clair Feilden was appointed to the staff to deal primarily with tropical questions. The Dominions and Crown Colonies were asked to appoint Official Correspondents for liaison purposes. Dr. W. T. Macoun was appointed for Canada and has since proved a tower of strength and help to us.

Having received, then, no particular instructions from the Imperial Agricultural Conference of 1927, we have tried to carry into effect the general recommendations of the Executive Council of the Imperial Agricultural Bureaux, as set out in their memoranda I-III. Very briefly, our aim is to act as a link between fruit research workers in the Empire and to make available to them the results of research in this field throughout the world.

*Presented to the Horticultural section of the Tenth Annual Convention of the C.S.T.A., Wolfville, N.S., June 25th, 1930.

†Chief Officer of the Imperial Bureau of Fruit Production.

Our first efforts were necessarily of a preparatory nature. Some of you may remember in the summer of 1929 receiving a circular letter with inevitable questionnaire attached. Its aim, now largely achieved, was to discover the point reached by horticultural research and the particular problems under investigation in every part of the Empire. At the same time foreign work was not neglected, and contact has been established with the more important research centres in Europe including Soviet Russia and with workers with the Far East and in America. We are particularly indebted to Dr. Auchter and his staff in the horticultural office of the Bureau of Plant Industry at Washington for their much appreciated help in the United States. I may say that our European contacts have already enabled us to arrange itineraries for Overseas' workers, who wish to see something of work on the European mainland.

An examination of some of the main features of our present work may show how we hope to achieve our aims. To reach our public some form of publication seems essential. I would here remind you of Hatton's simple but fundamental work at East Malling, with which you will be familiar, on the standardization of the rootstocks of deciduous fruit trees. I need only say that, apart from the considerable commercial possibilities involved, the value for experimental work of thus eliminating one variable factor has been recognized throughout the world. It was therefore decided that the first phase of fruit production to be investigated by our Bureau should be the plant material itself as used by the horticulturist. "Its identification, selection, propagation, standardization and the whole question of stock scion relationships in general are", to quote Hatton, "in the first instance being brought under review. Not only does the entire technique of field experimentation and of plot planting depend on this basic knowledge, but, as the physiological botanist, biochemist and plant pathologist have discovered, it is equally necessary for an accurate study of the functioning of the various aspects of the plant, its response to different treatments, and its degree of resistance to certain diseases. Evidence was to hand that investigators in fruit production and kindred crops throughout the Empire were still facing these initial problems whether in deciduous or tropical fruits and both on plants growing on their own roots (either from seed or from some form of layer) and in budded and grafted subjects. The ground being already generally explored by the circulation of the memorandum on 'The Standardization of Horticultural Material with Special Reference to Rootstocks' through the offices of the Empire Marketing Board, it was resolved by the Bureau to follow up in detail the general evidence already obtained, and as a result of the constant enquiries with regard to the position of such crops as rubber, coffee, tea and cocoa, to include these in the scope of the review". This then will form the subject of our first memorandum, which it is hoped to publish this year. The way will thereby be paved for subsequent reviews of the external factors affecting the growth of fruit trees, e.g., cultural practice, nutrition, soil and climatic conditions, etc. To deal adequately with such problems the Bureau must largely rely on help from the different research stations of the Empire, and I would make the most urgent appeal to all such to keep us informed

of the progress of their work, including the incidence of difficulties expected and unexpected.

In addition, suggestions from all quarters have shown that a periodical of a bibliographical nature, dealing with fruit production and possibly containing brief summaries, would be welcomed. Neither the difficulty involved in making our scrutiny wide enough to cover all journals which may occasionally contain a pertinent article, nor the problem of translation are negligible. We hope, however, that these may be overcome and that Empire horticulturists may soon be kept posted on the important literature touching their work.

The number of queries dealt with has been encouraging. They are coming from all parts and are of the greatest possible value to us as showing the particular problems at present exercising the minds of fruit specialists. Among others have been enquiries on the availability of published articles on vegetative propagation, on plot lay-out, on table-grape growing in Spain and in the Argentine, on sources of Avocado stocks, on ringing etc., etc. Where, as in the case of ringing, a query has seemed of sufficient general interest to warrant it, a short survey of current work on the subject has been made and issued in stencilled form as a technical communication.

The Bureau has taken advantage of the holding in London in August next of the International Horticultural Congress to call a Conference of Empire horticulturists on the days immediately preceding this Congress. Although the claims of other conferences have caused the disappointment of our most sanguine hopes as to the number of Canadian representatives, we are, however, fortunate in welcoming Dr. W. T. Macoun as official representative. We are assured of a paper from him, as also from several others of the Dominion, who cannot themselves be present, but who are generously contributing from afar to the success of the conference. We hope that not only the subjects under discussion may have considerable light thrown on them, but also that suggestions may be forthcoming as to most useful functioning of the Bureau.

I have, gentlemen, tried to give you some idea of our aims and of the steps we are taking to achieve them. The Bureaux have arisen as the expressed wish of workers throughout the Empire, and are supported by contributions from the Governments of the Empire. You are the patrons: we are at your service. I would appeal to you to work us hard and, by keeping us abreast of your current projects, enable us to serve well and truly the Empire to which we belong.

The following Bureaux are now established:

Imperial Bureau of:

Animal Nutrition—Rowett Research Institute, Bucksburn, Aberdeen, Scotland. Director, Dr. J. B. Orr, D.S.O., M.C., M.D., D.Sc.

Animal Genetics—Animal Breeding Research Department, Edinburgh University, Scotland. Director, Professor F. E. Crew, M.D., D.Sc., Ph.D.

Fruit Production—East Malling Research Station, East Malling, Kent, England. Director, Mr. R. G. Hatton, M.A.

Soil Science—Rothamsted Experimental Station, Harpenden, Herts, England. Director, Sir John Russell, O.B.E., D.Sc., F.R.S.

Plant Genetics (Herbage plants)—Welsh Plant Breeding Station, Aberystwyth, Wales. Director, Professor R. G. Stapledon, M.A.

Agricultural Parasitology—Institute of Agricultural Parasitology, St. Albans, England.

Animal Health—Veterinary Research Laboratory, Weybridge, Surrey, England. Director, Dr. W. H. Andrews, D.Sc., M.R.C.V.S.

SUMMARY

After an expression of thanks to the convention for hospitality the following points are noted:—

The origin of the Bureaux lay in the Imperial Agricultural Conference of 1927.

The Imperial Bureau of Fruit Production was set up in April 1929, its technical staff in June 1930 consisting of 1 Director, 2 technical officers, 1 secretary.

Its initial work has been preparatory.

Its aims is liaison and the supply of information.

Information will be disseminated by memoranda, a periodical of a biographical nature, and technical communications.

A conference of Empire Horticulturists has been called for August 5-7th, 1930.

The Bureau appeals for hard work and for information.

THE RELATION OF THE DOMINION BUREAU OF STATISTICS TO AGRICULTURAL ECONOMICS *

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Every economist working in the field of agriculture may improve his usefulness by a knowledge of the organization and scope of the Dominion Bureau of Statistics. Officially created in 1918 with the definite object of consolidating Canadian statistics through co-operation, it has had an evolutionary progress until it now covers all the important branches of Canadian social and economic life. The importance of such an organization to agricultural economists will be readily apparent. The social science investigator cannot employ the method of experimentation practised in the natural sciences. Two main methods of approach are open, the first being the survey method, whereby samples are isolated for particular study. This method has its particular use and definite value in investigations into hitherto unexplored fields. It is expensive, however, and the effect of high costs is often to reduce the size of the sample chosen and thus to make the data unrepresentative. The second method is by the statistical analysis of inductive facts such as are tabulated by small areas in the Census. This method of studying agricultural questions of a social and economic nature has not been sufficiently exploited in Canada. In the provision of basic data for the agricultural economist, the Dominion Bureau of Statistics is the greatest single source in Canada and its staff is sincerely anxious to encourage the use of census and other statistical material. Senior and graduate students will find at the Bureau a great fund of information for papers and theses, and professors will find much data interesting to their classes and helpful in research work.

According to the British North America Act, statistics form a subject of Dominion rather than Provincial legislation. This does not mean that the Provinces cannot collect statistics, but merely that the Dominion is responsible for their national organization. This right is crystallized in the Statistics Act of 1918 (8-9 Geo. V, Ch. 43), which establishes the Bureau to replace the 'Census and Statistics Office' which had been in existence since 1905.

The departmental organization of the Bureau gives a good idea of its comprehensiveness. There are 11 divisions, one of which is purely administrative. The others are Demography, Agriculture, Industrial Census, External Trade, Internal Trade, Finance, Education, Mining and Metallurgy, Transportation and Public Utilities, and General Statistics. Sub-divisions are concerned with statistics of business, forestry, fur farming and labour.

The Bureau is not entirely concerned with the collection, compilation, and publication of statistics. Their analysis is not neglected and economic research has been begun. The Bureau is the logical centre for Canadian social and economic research, and the expansion of this work is projected along with the encouragement of an increasing amount of private research.

*Presented to the Canadian Society of Agricultural Economics, Wolfville, Nova Scotia, June 26, 1930, meeting in conjunction with the C.S.T.A.

†Chief, Agricultural Branch.

Four branches of the Bureau are in fields particularly related to the work of agricultural economists. These are the Census, Agriculture, and Internal and External Trade. The relation of these branches to agricultural economics will be discussed in order.

The Census of Population and Agriculture is rightfully regarded as the most reliable source of agricultural statistics. Census records since the turn of the century are particularly valuable because of efforts to make data comparable in the reports since that time. Students of agricultural history, however, will find interesting and authentic information in the Census reports of the 17th, 18th, and 19th centuries. The primary object of the Census is the enumeration and description of the people, but associated with this demographic function is that of picturing the country, its wealth and its social and economic institutions at a point of time. The Census provides the most complete and accurate cross-section of the life of the nation. A major part of the expense of the Census-taking is in the enumeration of the rural population, so the collection of information about agriculture is justifiable to apportion the expense.

The make-up of a Census schedule requires great exercise of judgment. The questions must above all be practical and they must also be such as to require definite answers, with no possibility of misinterpretation. They must have an almost nation-wide application rather than a local significance. They must be simple and understandable to farmer and enumerator alike and because of this limiting factor, many of the points on which the agricultural economist wishes information are not answered directly in the Census, but must be secured by interpretation, analysis and correlation of related answers. Again, the make-up of a Census schedule requires sound judgment in maintaining a true proportion between the desire to have comparable information from one Census to another and the necessity of keeping up with agricultural progress. The Canadian Censuses since 1901 are especially notable in meeting the qualifications of comparability. Yet too much attention should not be paid to this fact—a Census schedule cannot be permanently fixed. In the fields of harvesting and farm transportation, for example, the enumeration of flails and canoes necessary for the 1871 Census must be changed to the combine and the automobile for 1931.

The Census information is particularly valuable to the agricultural economist because it is both accurate and detailed. It is based on the closest approximation to the totality of Canadian farms and the returns are compiled by counties and parishes in the East and by municipalities or Census divisions in the West. The Census is particularly informative in the study of population and of land utilization. The establishment of trends in these fields is largely made on the basis of ratio change (for instance, occupied acres per farmer), and where the two components of the ratio have been derived on a comparable basis as is the practice of the Census, they permit convenient and reliable comparisons. The Census also offers the best available data for the analysis of gross agricultural income as well as the important expenses of production. A further contribution of the Census is the information it yields on many related farm projects not covered by the annual agricultural statistics, for example, the enumeration of farm facilities and farm tenure.

In the field of agricultural statistics, the Census returns which appear every 5 or 10 years form the basic and most accurate statistics. Besides this foundation, the country also requires supplementary annual estimates and current monthly reports based on samples of varying size. The provision of these data is the function of the agricultural Branch of the Bureau.

Perhaps the closest approximation to the accuracy of the decennial Census in the field of agricultural statistics is attained by the card schedules distributed in June of each year for the enumeration of crop acreages and numbers of live stock. Schedules are usually filled in by 16-25 per cent of the total number of farmers in Canada, which constitutes a reasonable sample for estimation. In seven of the nine provinces, the distribution and collection of the cards are made to the farmers through the rural school teachers, while in Ontario and British Columbia, the distribution is accomplished through the post offices and the cards are returned direct to the provincial authorities for compilation. The acreage figures are secured from these reports by calculations from the basis of the total number of farms or in the case of Ontario, from the farm acreages. Later in the season when the crop-reporting forms give the average yield per acre, the acreages from the annual Census are employed to give the total production. Thus the great importance of correct acreage estimates. The total number of live stock in each province is derived from the Census sample in the same way as the total acreages.

The crop-reporting service of the Branch is its most important duty and because of the high place of agriculture in the country, the crop estimates rank as one of the most important statistical releases of the Bureau. The service for 1930-31 consists of 23 separate reports. On the principal spring cereals, there are three numerical condition reports, twelve telegraphic reports, one preliminary estimate of acreage sown, three estimates of yield, and one release giving the carryover at July 31st. The dates of these reports are carefully planned to give the most comprehensive and timely information on the progress of the crops.

The crop-estimating is done on the basis of correspondents' reports. In each province, there is a staff of farm correspondents, and in addition to practical farmers in the West, the Bureau also relies on reports from bank and elevator managers, railway station agents, rural postmasters, and by an innovation in Alberta, the Provincial Police. The importance of a wide sample will be readily realized. In practice, an actual downward bias in farmers' estimates occurs so that reports from other sources are necessary correctives. The returns should be of such a number and breadth that they may be relied upon entirely, so that individual judgment is unnecessary.

The crop-reporting service of the Bureau began in 1908 and since that time has been extended and fused with the provincial systems. Every effort is now made to avoid duplication and contradiction in the official estimates. Previously, this was not the case.

Intended to supplement the estimates of grain yields made from the returned schedules, a research project is under way in the Branch to study the relation of the weather and crop yields. Using the wheat crop in Saskatchewan for the original attack, a fairly definite and high correlation of weather factors

and wheat yields has been obtained. While being subjected to further testing, the estimations from this formula are not yet published by the Bureau.

The second large division within the Agricultural Branch covers the statistics of distribution, chiefly the grain trade and the live stock market. Important statistics of the grain trade such as stocks, receipts and shipments, are published weekly, while an annual report covers the whole crop year. Monthly publications report the statistics of the milling industry and of sugar holdings. Neither a monthly nor a weekly publication appears for live stock because this field is ably covered by the Markets Intelligence Division of the Dominion Live Stock Branch. A yearly report on live stock and live stock products appears and the more important statistics on prices and stock movement are printed in the Monthly Bulletin of Agricultural Statistics. Cold storage holdings are issued by press letter monthly.

Miscellaneous statistics of agriculture are compiled from special schedules and reports. Examples are the statistics on maple sugar and syrup, farm wages, stocks on hand, and stocks of merchantable quality. A new departure of the month of June is the collection of a series of prices received by farmers for their important products. This has long been needed by students of agricultural prices and it is intended to establish an index of farm prices and project this back as far as possible. The response to the first schedule issued in June was most encouraging. When such an index is available, we will have a much more reliable indication of how farm prices compare with the general price level and with the prices paid by farmers for their implements and supplies.

Throughout all the work of the Agricultural Branch, great benefit results from consultation and co-operation with other departments of the government service and with the provincial governments. Various branches of the Dominion Department of Agriculture are especially liberal with their assistance. Officers of the Dominion Experimental Farms perform a major service in connection with the telegraphic crop reports.

For the compilation and publication of the index numbers of wholesale and retail prices, the Internal Trade Branch of the Bureau is responsible. Among the divisions of wholesale prices according to origin is found an "index of Canadian farm products," which is further subdivided into field and animal products. This offers the best available criterion of farm price change in Canada. It offers the prospect of interesting comparisons with changes in the wholesale all-commodity index and in the index of prices paid for consumers' goods.

The Internal Trade Branch also publishes indexes of security, stock and bond prices—all of which are valuable in some branch of agricultural research.

Another Branch of the Bureau which contributes information of value to the agricultural economist is that of External Trade. From this Branch are secured the imports and exports of agricultural products. Both the Internal and External Trade Branches publish their important statistics in monthly and annual publications.

Students of agricultural history in Canada will find considerable difficulty in securing figures suitable for their purpose. Previous to 1908, the Census is practically the only reliable source. Since 1908, the co-operation between the Bureau and the Provinces has been a considerable help through the elimination of conflicting figures and improvement has been continually noticeable.

In the field of international statistics a close relation has been established between the Bureau and the International Institute of Agriculture. Anyone who has tried, for instance, to compare the numbers of live stock in the different countries of the world knows the present futility of such an undertaking and realizes the necessity of consolidating the methods of collection, compilation and publication. This is a major task of the International Institute. In connection with Census-taking in various countries of the world for 1930 and 1931, the Institute has made an earnest endeavour to have the questions on the schedules made effective and comparable. To this end, the Bureau is co-operating in every possible way.

Few Canadians realize that the organization which has co-ordinated and centralized the statistics of Canada serves as a model for other countries in this respect. Few of us have considered the existing inter-relations between the various branches of statistics—of population, agriculture, industry, and trade—and the advantages that must ensue when statistics are collected under one comprehensive plan and compiled by comparable methods. May I conclude with the expressed wish that members of the Canadian Society of Agricultural Economics should establish a connection with the Bureau on the first occasion when statistical data are necessary in their work. I know that they will find the members of its staff sincerely anxious to be helpful in the encouragement of economic investigation.

SEED SETTING IN ALFALFA *

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The cause of the frequent light seed crops of alfalfa has been a subject of considerable speculation and of some investigation during the last two or three decades. Failures have been attributed to unfavourable weather conditions at certain critical stages in floral development, to rapid vegetative growth during the flowering period due to excessive soil moisture, to damage by thrips during either pre- or post-fertilization stages, or to the scarcity of certain bees and insects which are able to effect tripping and thereby facilitate fertilization of the flowers.

The relation of tripping in particular has received some attention by certain investigators and has been studied to some extent recently at the University of Alberta. This paper is intended to review briefly some of the literature dealing with the problem of seed setting in alfalfa and to present data obtained by the authors in the growing seasons of 1926, 1927 and 1929, concerning the relation of tripping to seed setting and also concerning the prevalence of sterile pollen.

REVIEW OF LITERATURE

Moisture conditions have been found to exert an important effect on seed-setting in alfalfa. Stewart (13) states that all the large alfalfa seed-producing zones are in arid or semi-arid regions. When an abundant supply of soil moisture is present, alfalfa grows very rapidly and gives a high hay yield but sets little seed. During the growing of the seed crop it seems necessary that a constant supply of moisture be maintained somewhere within reach of the plant, but at no period should it be so easily available as to induce rapid vegetative growth. Blinn (3) found at the Colorado Experimental Station that alfalfa seed failed to set under field conditions probably because of the abnormally wet weather during the spring and summer months, yet plants grown in cement pots which received heavy applications of water set seed fairly well. When water in varying amounts was applied to plants grown in cement pots, the results did not show that alfalfa seed yields could be controlled by the application of any definite amount of water. This would seem to indicate that there are other factors influencing seed-setting besides any particular moisture supply.

Martin (9) found that the failure to obtain seed results from two causes, viz., the failure of the pollen to germinate and the "blasting" of the seed. The germination of the pollen depends upon a proper supply of moisture. There must be a certain ratio between the moisture given off by the stigma and the moisture of the surrounding air. The "blasting" of seed is caused by the arrested development of the embryo owing either to the plant's inability to furnish the proper water and food supply for the maturing

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of the seed during drought or to some pathological conditions to which the seed is more susceptible under drought conditions.

Heat and light also seem to be important climatic factors. Piper and his co-workers (10) have shown that hot sunshine induces automatic tripping, that is, tripping without the assistance of other natural agencies such as insects. Piper also found that few flowers formed pods unless they became tripped. Aicher (1) believes that there is a close correlation between the number of days of sunshine during the summer season and the amount of seed-setting. Blinn (3) found that plants growing along the edge of a dry bare ditch set seed heavily on the branches nearest the ground, while the remaining branches were practically barren of seed. This, he thought, could be accounted for by the dry, sandy surface reflecting both heat and light.

Gray (6) working at Lethbridge, Alberta, found that the wind is a very ineffective agent for tripping alfalfa blossoms and is of value in only the most unusual cases.

Brand and Westgate (4) have drawn attention to the importance of insects in bringing about the pollination of alfalfa flowers. Pollination may be effected by long-tongued insects such as leaf-cutter bees (*Megachile* spp.) and bumblebees (*Bombus* spp.) or by automatic tripping. It would seem that pollination by insects brings about cross-fertilization, while automatic tripping results in self-fertilization. In the opinion of Professor Strickland, Entomologist at the University of Alberta, the leaf-cutter bee is very common throughout Alberta.

Piper et al (10) found that bright sunshine induces automatic tripping. Owing to the latter phenomenon it is possible to obtain good seed yields in regions where insects adapted for tripping are not numerous. According to Stewart (13) alternating spells of cloudy and bright weather with moderate wind and occasional showers are considered favourable for automatic tripping.

Hay (7) has studied the effect of artificial tripping on seed-setting at Lethbridge, Alberta. He found that about 9.5 per cent of the artificially tripped flowers and about 5.9 per cent of the flowers used as checks set seed and concluded that with such a low percentage of seed pods from the flowers tripped, even though it was almost double that from the checks, lack of tripping was not the limiting factor. He found that neither the time of day when the tripping was effected nor the colour of the blossoms showed any relation to seed-setting. Southworth (12) has emphasized the importance of the amount of tripping in determining the seed yield. Carlson (5) studied the seasonal behaviour of alfalfa flowers as related to seed production. He found that when alfalfa flowers are from one to three days in the full-bloom stage and from two to five days in the wilted stage, the chances are greatest that they will form seed pods. He also found that alfalfa flowers are capable of forming pods rather freely in the absence of tripping.

Seamans (11) found that alfalfa thrips, especially *Frankliniella occidentalis* Pergandi, are very prevalent in Alberta, and that seed production in alfalfa is materially reduced by these insects in two ways. The most severe losses are caused by the thrips feeding on unopened buds, while lesser losses are caused by the thrips feeding on the ovaries of unopened flowers or on young seed pods.

Jenkin (8) has reported on the investigation of the problem of seed-setting in alfalfa which Torsell is carrying out at Ultuna, Sweden. Torsell is investigating the question of male sterility which he believes may be of importance either because high male-sterility and low seed-setting capacity result from the same cause or because low seed-setting may be due at least partly to poor self-pollination or else to an actual shortage of pollen in the vicinity. Jenkins states: "Mr. Torsell's view is that the amount of seed set depends upon climatic conditions, upon the amount of pollen available and upon the presence of the agents of cross pollination, but even where all these conditions are favourable, some plants are yet poor seed producers."

EFFECT OF ARTIFICIAL TRIPPING ON SEED-SETTING IN ALFALFA

The relation of tripping to seed production was studied at the University of Alberta in the summers of 1926, 1927 and 1929. In 1926 some branches of alfalfa plants were enclosed in glassine bags in order that setting in bags might be compared with setting under normal conditions. Some plants set seed more readily than others. To overcome this difficulty, different branches of the same plants were subjected to the various treatments. The results obtained are shown in table 1.

TABLE 1. *Effect of tripping and bagging on seed-setting of alfalfa plants of various strains, 1926.*

| Treatment | Flowers Bagged | Flowers left exposed |
|----------------------------------------|----------------|----------------------|
| Number of plants tested | 43 | 43 |
| Number of flowers tested | 2426 | 2380 |
| Number of flowers artificially tripped | 1292 | 1148 |
| Number of above setting seed | 574 | 488 |
| Percentage of above setting seed | 44 | 43 |
| Number of flowers not tripped | 1134 | 1232 |
| Number of above setting seed | 77 | 288 |
| Percentage of above setting seed | 7 | 23 |

These results would indicate that artificial tripping increases considerably the percentage of seed set, but even where each individual flower is tripped less than one-half of them set seed. Artificially tripped flowers apparently set seed equally well whether bagged or not, but when untripped flowers are bagged they set very little seed. Failure to set seed in the latter case is probably due to the exclusion of insects, and possibly also to the exclusion of sunshine and to the lack of a free circulation of air.

The investigation of the effects of artificial tripping of exposed (unbagged) flowers on seed-setting was continued in 1927 and in 1929. The data for the three years are given in table 2. These results indicate that artificial tripping has a very considerable effect in increasing the seed yield. This finding is in accord with that obtained by other workers. It is interesting to compare the results obtained at Edmonton with those obtained by Hay (7) at Lethbridge. Hay found that about 9.5 per cent of the artificially tripped flowers and about 5.9 per cent of the untripped flowers set seed. It will be noticed that the percentage of seed set is very much lower although the relative effect of artificial tripping is about the same. It should be remembered, however, that Hay carried out his work during a different season, and that

at Edmonton plants spaced three feet each way were used while at Lethbridge the plants were grown in rows. It is generally recognized that plants widely spaced tend to set seed more freely than those closely spaced. However, a comparison of the Lethbridge and Edmonton results suggests the possibility of conditions being somewhat more favourable at Edmonton than at Lethbridge for seed setting.

TABLE 2. *Effect of artificial tripping on seed-setting of alfalfa plants of various strains, the flowers remaining unbagged.*

| Treatment | 1926 | 1927 | 1929 |
|----------------------------------------|------|------|------|
| Number of plants tested | 85 | 24 | 17 |
| Number of flowers tested | 9277 | 2271 | 3359 |
| Number of flowers artificially tripped | 4662 | 1150 | 1628 |
| Number of above setting seed | 1648 | 476 | 729 |
| Percentage of above setting seed | 35 | 41 | 45 |
| Number of flowers not tripped | 4615 | 1121 | 1731 |
| Number of above setting seed | 1037 | 225 | 388 |
| Percentage of above setting seed | 22 | 20 | 21 |

POLLEN STERILITY

While studying pollen development in alfalfa it was observed that in many plants pollen grains which possessed no protoplasmic contents and were therefore undoubtedly sterile, were of very frequent occurrence. Consequently pollen of a large number of flowers from different plants was examined in order to secure some idea of the prevalence of pollen sterility and of its variability in different plants. The pollen specimens were stained with iodine

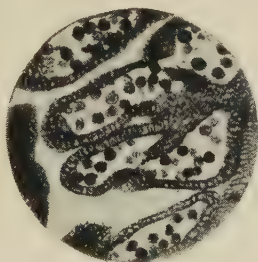


Figure 1. Section of anthers showing small and sterile pollen grains.

and examined under a microscope. In order to keep conditions as uniform as possible, counts of the number of fertile and sterile grains were made in all cases from flowers at the erect standard stage, that is, when the flowers were ready for tripping but had not yet tripped. Grains possessing protoplasmic contents were counted as being fertile, an assumption which may or may not be true. It should be borne in mind, therefore, that the minimum percentage rather than the total percentage of sterile pollen was determined by this method. The results of the pollen counts from a number of plants, all of the Grimm variety, are given in table 3.

TABLE 3. *Pollen sterility in Grimm alfalfa.*

| Plant No. | Pollen grain counts and percentage of sterile pollen | | | | | |
|-----------|------------------------------------------------------|--------------------|----------------------|--------------------|----------------------|--------------------|
| | 1926 | | 1927 | | 1929 | |
| | Total number counted | Percentage sterile | Total number counted | Percentage sterile | Total number counted | Percentage sterile |
| 10.1 | 229 | 15 | 308 | 5 | 487 | 11 |
| 10.1 | 487 | 14 | 673 | 12 | — | — |
| 10.1 | — | — | 588 | 11 | — | — |
| 20.1 | 591 | 5 | 509 | 4 | 414 | 6 |
| 20.1 | 391 | 3 | 677 | 3 | 550 | 6 |
| 42.1 | 733 | 17 | 476 | 10 | — | — |
| 42.1 | 508 | 20 | — | — | — | — |
| 42.1 | 278 | 16 | — | — | — | — |
| 43.1 | 477 | 25 | 524 | 21 | 439 | 29 |
| 43.1 | 188 | 36 | — | — | 444 | 26 |
| 43.1 | 422 | 24 | — | — | — | — |
| 46.1 | 263 | 16 | 443 | 15 | 342 | 13 |
| 46.1 | — | — | 527 | 11 | 425 | 16 |
| 33.1 | 310 | 35 | 490 | 26 | 519 | 48 |
| 33.1 | 466 | 31 | — | — | 353 | 41 |
| 35.1 | 511 | 27 | — | — | — | — |
| 35.1 | 295 | 29 | — | — | — | — |
| 69.1 | 308 | 4 | 365 | 12 | 546 | 6 |
| 69.1 | 323 | 8 | 679 | 7 | 515 | 7 |
| 69.1 | 164 | 6 | — | — | — | — |
| 69.1 | 385 | 9 | — | — | — | — |
| 69.1 | 567 | 8 | — | — | — | — |
| 69.1 | 346 | 7 | — | — | — | — |
| 70.1 | 302 | 3 | 503 | 12 | 478 | 3 |
| 70.1 | 310 | 7 | 589 | 7 | 526 | 6 |
| 70.1 | 214 | 4 | — | — | 497 | 5 |
| 70.1 | 428 | 3 | — | — | — | — |
| 71.1 | 264 | 5 | 319 | 8 | 466 | 14 |
| 71.1 | — | — | 730 | 7 | 488 | 7 |

From the data presented in table 3 it will be seen that within rather wide limits, the percentage of empty pollen grains found in different flowers of the same plant is constant. Counts made several days apart from different flowers belonging to the same plant showed no significant fluctuation in the percentage of sterile pollen. Wide variations are frequently found, however, between different plants, even though they belong to the same variety or strain. These differences appear to remain fairly constant from year to year.

In 1926 a single Grimm alfalfa plant was transferred from the field to the greenhouse where it was divided into two equal parts. One half was grown under hot, moist conditions, the other half under cool, moist conditions. A number of pollen counts were made and the percentage of sterile pollen was found to be about the same for each half. This experiment did not indicate that temperature differences alter the percentage of sterile pollen.

Alfalfa flowers were obtained from both the Brooks and Lethbridge districts. Pollen counts failed to show any appreciable difference in the percentage of sterile pollen formed in flowers from these two sources.

In practically all species of flowering plants, the amount of pollen produced is greatly in excess of fertilization needs. On this account it would seem possible that rather high proportions of defective pollen might occur without appreciably reducing the amount of seed set. At any rate it would appear reasonable not to expect a high correlation between the percentage of sterile pollen and the amount of seed set providing the pollen produced is not almost entirely sterile. However, in 1929 counts were obtained from a number of alfalfa plants, which were setting practically no seed under field conditions. These were found to have a high percentage of empty grains, ranging from 50 per cent to 90 per cent for different plants. As the proportion of sterile pollen produced by any given plant seems to be constant, and as the percentage is frequently very high, it may well be that this seemingly inherent difference will account in part at least for the wide fluctuations in seed-setting capacity exhibited by different plants of the same strain. It would certainly seem to form an important consideration to be borne in mind by the plant breeder.

SUMMARY

1. Literature is reviewed, which considers seed setting in relation to the various factors—soil moisture, atmospheric moisture, heat, light, wind, prevalence of tripping agencies, damage by thrips, pollen sterility and variability in the inherent capacity of individual plants to set seed.

2. Untripped flowers enclosed in bags were found to set seed less freely than flowers which were left uncovered. Artificial tripping was found to increase considerably the extent of seed-setting and hence the seed yields.

3. Many plants produced high percentages of sterile (empty) pollen grains. The percentage varied among plants but remained constant for particular plants even when the pollen was produced under different conditions.

4. The variable production of sterile pollen among plants is a matter of important consideration for the plant breeder.

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THE SOURCE AND NATURE OF VARIABILITY IN A STRAIN OF MARQUIS WHEAT.

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The awakening of a strong "varietal consciousness" with respect to cereal crops during the past few years has brought about a renewed interest in the variability within wheat varieties. In Western Canada Marquis occupies far more land than all other wheat varieties together, but during its twenty years of economic existence it has become more or less contaminated by admixture of other varieties and by natural crossing. Furthermore, the steadily rising standards of purity of the Canadian Seed Growers' Association have drawn attention to small inherent variations in Marquis that hitherto passed unnoticed. As standards rise the problem of purification becomes urgent and a better understanding of the cause and nature of the impurities becomes essential.

Several studies on mixtures and variations in Marquis wheat have been made during recent years. Newman (5), Quisenberry, Clark and Bayles (6) and Harrington (2, 3) found a wide range of mixtures and off-types in Marquis and concluded that natural crossing probably caused much of the variation. Progeny tests of non-typical Marquis plants made by Harrington (2)† and Newman (5) have shown that the more outstanding off-types in Marquis usually yielded off-type progeny, whereas plants selected as minor off-types sometimes proved to be typical Marquis. DeLong (1), in studying the effects of extreme environmental conditions on Marquis, found that fairly wide variations could occur. Newman (5) and Harrington (4), however, found that the effects of environmental influences on plants which had a reasonably good opportunity to grow were relatively unimportant.

The present study was made for the purpose of, (1) ascertaining more definitely the responsibility of natural crossing for Marquis variability and (2) determining the nature of Marquis off-types especially with respect to the inheritance of critical spike and glume characters. Marquis 7, one of the non-uniform strains upon which the writer (2) reported in 1927 was found to be very suitable material for this study owing to its consisting of two main types of plants and a large proportion of intermediates.

MATERIAL USED

In 1925, 1220 single plants of Marquis 7 were harvested at random and classified under three general headings, viz: Type C‡ or typical Marquis, Type B‡ differing distinctly from Marquis in spike shape, spike density, glume shape, beak shape, and various other characters, and Type A consisting of (a) a large proportion of plants more or less intermediate morphologically between Types C and B, and (b) a small proportion of plants differing widely from Types B and C in one or more characters. It was shown that the stock of Marquis 7 investigated consisted of 43 per cent of typical Marquis

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†Also unpublished results obtained at the University of Saskatchewan.

‡In a previous paper (2) on these Marquis 7 selections Types B and C were designated as Types II and III, respectively.

or Type C, 34 per cent of Type B and 23 per cent of Type A. Descriptions of Types C and B with respect to the differential morphologic characters used in this study are given in Table 1. Representative spikes and glumes of these types are shown in Figures 1 and 2.

Since character variation in Marquis 7 is seen best in Type A material this study was confined to progeny tests of Type A selections. The Type A plants and their offspring were classified for each character according to their resemblance to Types C and B, as follows: C = like Type C; I = intermediate between Types C and B; B = like Type B; IC = intermediate between C and I; IB = intermediate between I and B; O = not falling into any of the foregoing classes, being either beyond the outer limits of Types B and C or else altogether different from these types.

Seasonal influence on the characters studied was clear cut though slight. For example, in 1925 and 1926 the shoulders of the glumes were squarer than in 1927 and 1928 and the glumes themselves were shorter. Again, in 1928 the spikes were less fusiform and the beaks blunter than in 1927. Such influences affected all of the material and could be discounted without much trouble excepting in the case of spike shape where some difficulty was experienced.

TABLE 1. *Detailed comparative description of Types C and B for four distinctive characters.*

| Type | Description |
|----------------------|-------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| <i>Spike Shape</i> | |
| C. | Fusiform with weak development of spikelets at base and tip. |
| B. | Fairly cylindrical with strong development of spikelets at both base and tip and a moderate but definite clavateness. |
| <i>Spike Density</i> | |
| C. | Mid-dense, ten central internodes average about 55 mm. |
| B. | Dense, ten central internodes average about 45 mm. |
| <i>Glume Shape</i> | |
| C. | Keel may be straight but generally bows out slightly in the top two-thirds and then curves slowly in to a base of medium width. Glume widest at about two-fifths the distance from base to shoulder. Shoulder rounded to square, of medium width. |
| B. | Keel sometimes straight but usually bows in slightly commencing just below the beak and finally curves fairly abruptly in to the base, which is slightly pinched. Glume widest at about one-third the distance from base to shoulder. Shoulder rounded and usually slightly narrow. |
| <i>Beak Shape</i> | |
| A. | Closely like an isosceles triangle with fairly horizontal base. Beak length slightly exceeds width of base. Sides of beak almost straight with tendency for the shoulder side to be at a greater angle with the base than the keel side. Apex slightly rounded (acute). |
| B. | Thimble shaped and usually distinctly bulged at the middle with the shoulder side reaching the shoulder at a fairly sharp angle. The keel side curves gradually down and outward to form the top of the keel's upper curve when that is present. The apex is fully rounded. There is usually a slight but distinct appearance of the beak tipping in over the shoulder. |

PROGENY TESTS OF THE ORIGINAL SELECTIONS

Progenies of the 1220 selections were grown in 1926 and studied individually. Most of these proved uniform. A few lacked uniformity and



Figure 1. Representative spikes of the two main types of Marquis 7: Type C at the right; Type B at the left.

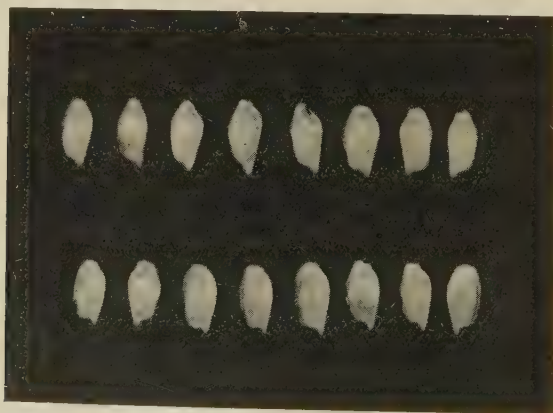


Figure 2. Representative secondary glumes of the two main types of Marquis 7: Type C in the upper row; Type B in the lower row.

appeared to be segregating for various spike and glume characters. Others were uniform excepting for one or two plants. No progenies whose mother plants were classified as Type B, proved to be Type C, nor did any progenies placed with Type C prove to be Type B. Some of the progenies from mother plants that had been considered slightly intermediate, and therefore classified as Type A, proved to be Type B and others to be Type C. Most of the Type A progenies were unquestionably intermediate in one or more characters.

PROGENY TESTS OF TYPE A PLANTS FROM THE 1925 NURSERY

Progenies of thirty-two Type A plants from the 1925 nursery were grown in 1927 and compared with the mother plants. The results for spike density, glume shape and beak shape are given in Table 2. Two of the 32 progenies proved to be typical Type C. The mother plants in these two cases (lines 657 and 682) were recorded as being only slightly off from Type C. Five lines (392, 600, 1088, 686 and 814) were not typical intermediates between Types C and B. Most of the remaining twenty-five lines were intermediate. Some of them (lines 689, 776, 789, 833 and 677) approached C fairly closely. Others (lines 498 and 729) leaned strongly toward Type B. Nine of the twenty off-type lines in section I of the table (lines in which a number of plants were studied) appeared to be heterozygous for one or more of the three characters used.

Most of the Type A lines resembled Type C in spike density and leaned more strongly toward C than toward Type B in the other two characters. Possibly this may be due to Type A plants which approached Type B in general appearance, being wrongly classed as Type B. Such a systematic error might easily have occurred since one of the two supposed parental types (Type C) represents typical Marquis with definitely known characters and a fairly well defined range of allowable variation, whereas the other (Type B) represents a distinct departure from Marquis type with characters and variation limits not sharply defined.

On the whole the classification and description of the plants grown in 1925 is in accord with the classification and description of their progenies. Thirty of the thirty-two plants classified as Type A proved to be so, and the two that did not had been recorded as closely approaching Type C. In relatively few cases (eight out of sixty-six) did the progeny test show a plant to be more than one class value different than it had been described. A difference of one class value between parent and progeny is not very important owing to the variation allowable within any given class value. In no case did a parental description for a given character deviate more than two class values from the progeny results. This was true with respect to both uniform and non-uniform progenies.

A progeny was recorded as uniform or homozygous for a given character if the total spread was not over three class values with the mean at or near the middle class. It should be kept in mind that the total range between the extremes for any one character is relatively small. Small genetic differences may be easily masked by environmental effects. As the spread included in one class value is very small, differences of one class value cannot be attributed

to heredity any more than to environment. Therefore, where heterozygosity involves, say an *actual* total spread of only three class values, it is easy to see that no proof of heterozygosity exists. Conservely, where a line is homozygous and the results show an *apparent* total spread of three classes with the mean at or near the middle class, no exact proof of homozygosity exists. In other words, where small differences are concerned it is not possible to determine exactly whether or not these differences are genetic or environmental.

TABLE 2. *Description of a random group of 32 Type A plants and their progenies with respect to three characters that differentiate Type B from Type C.*

| Plant or line number | Parent 1925 | | | Progeny 1927 | | | Remarks |
|----------------------------|------------------|----------------|---------------|------------------|----------------|---------------|-------------------------|
| | spike density | glume shape | beak shape | spike density | glume shape | beak shape | |
| Section I.* | | | | | | | |
| 392 | C | B | I | C | I | I | Long spikes and glumes |
| 393 | C | I | I | IC | IC | IB | Short beaks |
| 397 | C | O | I | Seg. | Seg. | I | |
| 600 | C | O | O | I | O | O | V. short glumes & beaks |
| 657 | C | C | IC | C | C | C | Typical Type C |
| 678 | I | I | I | IC | Seg. | Seg. | |
| 689 | IC | O | C | IC | C | C | |
| 760 | C | C | I | IC | Seg. | Seg. | |
| 776 | C | I | I | IC | IC | IC | |
| 785 | IC | IB | I | IC | IB | Seg. | Spikes clavate |
| 789 | C | O | I | C | C | IC | |
| 833 | C | IC | IC | C | IC | IC | |
| 857 | C | I | I | C | IC | B | |
| 902 | IC | C | I | IC | IC | I | |
| 904 | IC | I | I | IC | I | I | Long beaks |
| 934 | C | O | O | Seg. | O | Seg. | |
| 1083 | IB | I | I | I | Seg. | Seg. | |
| 1088 | IB | I | I | Seg. | O | O | V. short broad glumes |
| 1095 | I | O | O | I | Seg.† | Seg.† | |
| 1127 | IC | IC | C | I | IC | Seg. | |
| 1134 | C | I | I | Seg. | Seg. | Seg. | |
| Section II.* | | | | | | | |
| 497 | IC | I | I | I | I | I | |
| 498 | IC | B | B | IC | IB | IB | |
| 569 | C | C | I | C | IC | IC | Long beaks |
| 618 | IC | C | I | IC | Seg. | Seg. | |
| 677 | IC | I | I | C | IC | IC | |
| 682 | C | O‡ | O‡ | C | C | C | Typical Type C |
| 686 | C | O | B | Seg. | O | B | Short broad glumes |
| 729 | IB | IB | IB | IC | IB | IB | |
| 780 | C | I | I | C | IC | IC | |
| 814 | C | I | I | C | O | O | Long narrow glumes |
| Section III.* | | | | | | | |
| 655 | C | C | C | C | C | C | Included as check |
| 782 | C | C | C | C | C | C | Included as check |
| 824 | C | C | C | C | C | C | Included as check |

*Section I includes all lines in which 12 to 15 progeny plants grown in 1927 were studied. Section II includes lines of which only two representative progeny plants grown in 1927 were studied and definite indication of heterozygosity was not recorded. Section III comprises some Type C checks.

†Several plants had much longer glumes and beaks than Types B or C.

‡The glume and beak appeared to be longer and narrower than in typical Type C.

NOTE: C=like Type C; I=intermediate between Types C and B; B=like type B; IC=intermediate between Type C and I; IB=intermediate between Type B and I; O=not like Types B or C or intermediate between them; V=very; Seg.=segregating.

The off-type characters, designated by 0 in the table, require special consideration. Both parent and progeny plants sometimes had character development sufficiently unlike that covered by the classes C, IC, I, IB, and B to warrant the special designation 0 indicating some inheritance outside of Types C and B. For example Mother plant 600 had glumes and beaks that were very much shorter than are found in either Type C or B. The progeny test proved this character to be quite definitely an off-character due either to transgressive segregation in a Type C \times Type B natural cross, or to natural crossing between either Type C or B and some variety other than Marquis. Line 934 presents a somewhat similar case.

Some mistakes in classification are inevitable when inheritance of small characters is being considered. In line 1088 the glume and beak characters of the mother plant appeared to be intermediate but proved in progeny test to be off-type. In this case the shortness of glume and beak were not as pronounced in the mother plant as in mother plant 600 previously referred to. A different sort of case is that of line 789 where the glume was recorded as off-type on account of being rather long, but the progeny test showed that this was not an inherited off-typeness.

TABLE 3. *Progeny test of some representative Type A plants from Marquis 7.*

| Line number | Parent 1927 | | Progeny grown in 1928 | | | | |
|-------------|-------------|------------|-----------------------|---------------|-------------|------------|-----------------|
| | Glume shape | Beak shape | Spike shape | Spike density | Glume shape | Beak shape | |
| I-28- 87 | IC | I | I | IC | IC | IB | Typical Type C |
| " 88 | I | IC | C | C | C | C | |
| " 89 | C | IC | C | C | C | IC | |
| " 90 | IC | IB | Seg. | Seg. | Seg. | Seg. | Some dwarfs |
| " 91 | I | I* | B | B | IB | IB* | |
| " 92 | C | IC | C | C | C | IC | Tall plants |
| " 93 | IB | IB | Seg. | Seg. | Seg. | Seg. | |
| " 94 | C | IC | I | IC | I | IC | Typical Type C. |
| " 95 | I | IC | C | C | C | C | |
| " 96 | I | IB | I | IC | Seg. | Seg. | |
| " 106 | C | IB | C | C | IC | IB | |
| " 107 | O | O | C | C | Seg. | Seg. | |
| " 108 | IC | I | C | C | IC | IC* | |
| " 109 | I | I* | C | C | IC | IC* | |
| " 110 | O | O | O | C | O | O | |

*Beak of greater length than in normal Marquis. This off-type character represents transgressive segregation or else is due to some other cause than crossing between 7B and 7C.

PROGENY TESTS OF TYPE A PLANTS FROM THE 1927 NURSERY

Fifteen representative Type A plants were taken in 1927 from a plot of Marquis 7 and given a progeny test in 1928. The data appear in Table 3. No record of spike characters was kept on the 1927 mother plants aside from the general designation Type A. Progeny tests showed that thirteen of the plants were Type A, and four were Type C. Four of the Type A progenies segregated and nine appeared to be uniform. In general the agreement between parent and progeny was good. In three instances out of twenty-two comparisons there was a deviation of more than one class value between parent and progeny. In two of these cases the mother plant was described as I in glume shape but the progeny was recorded as C.

TABLE 4. *Three generations of three representative Type A lines compared for critical spike and glume characters.*

| Plant or line number | Parent 1925 and immediate progeny 1927 | | | | Second generation progeny 1928 | | | |
|----------------------|----------------------------------------|---------------|-------------|------------|--------------------------------|---------------|-------------|------------|
| | Spike shape | Spike density | Glume shape | Beak shape | Spike shape | Spike density | Glume shape | Beak shape |
| 528-P | C | C* | I | I | | | | |
| 528-1 | C | C* | I | I | C | Seg. | Seg. | Seg. |
| -2 | C | C* | I | I | C | C | Seg. | Seg. |
| -3 | C | C* | B | I | C | C | Seg. | Seg. |
| -4 | IC | C* | IC | IC | C | IC | C | C† |
| -5 | IC | C* | I | I | C | IC | Seg. | Seg. |
| -6 | IC | C* | I | I | C | C | C | C |
| -7 | C | C* | I | I | C | C | C | IC |
| -8 | C | C* | IC | IC | C | C | C | IC |
| -9 | C | C* | I | IB | C | IC | Seg. | Seg. |
| -10 | C | C* | I | IB | Seg. | Seg. | Seg. | Seg. |
| -11 | IC | C | IB | I | C | Seg. | Seg. | Seg. |
| -12 | C | C* | B | IB | Seg. | Seg. | Seg. | Seg. |
| -13 | C | C* | I | IC | C | C | C | IC |
| Progeny means | C | C* | Seg. | Seg. | C | Seg. | Seg. | Seg. |
| 766-P | I | IC | IC | I | | | | |
| 766-1 | I | C | IC | IC | I | IC | I | I |
| -2 | I | C | I | I | C | C | I | I |
| -3‡ | IC | C | I | IC | I | I | I | I |
| -4 | I | I | I | I | I | I | I | IB |
| -5‡ | I | IC | IC | IC | IC | IC | I | IB |
| -6‡ | I | IC | I | I | C | C | I | I |
| -7‡ | I | C | IC | I | I | C | I | I |
| -8 | IC | C | I | I | C | C | I | I |
| -9 | I | I | I | I | C | C | I | I |
| -10x | IC | IC | I | I | C | C | I | I |
| -11 | IC | C | I | I | I | I | I | I |
| -12 | I | IC | I | IB | I | I | I | IB |
| Progeny means | I | IC | I | I | I | IC | I | I |
| 786-P | I | IC | I | I | | | | |
| 786-1 | IC | I | IB | I | IC | I | IB | I |
| -2 | I | I | B | I | I | I | B | I |
| -3 | IC | IC | IB | I | IC | I | I | IB |
| -4 | I | IC | IB | I | I | I | IB | I |
| -5 | I | I | IB | I | IC | IC | B | I |
| -6 | IC | IC | IB | I | IC | IC | B | I |
| -7 | I | I | IB | I | IC | I | IB | I |
| -8 | I | IC | IB | I | IC | I | IB | I |
| -9 | I | IC | IB | IB | I | I | IB | IB |
| -10 | I | I | I | IB | I | I | IB | I |
| -11 | I | IC | IB | I | I | I | Seg. | Seg. |
| -12 | I | I | IB | I | I | I | IB | I |
| -13 | I | IC | IB | IB | I | I | IB | I |
| -14 | I | IC | IB | I | I | I | IB | I |
| Progeny means | I | IC | IB | I | I | I | IB | I |

P—Parent.

*—Much laxer than Type C.

†—Much longer than Type C.

‡—Several dwarf plants appeared in the 1928 progeny.

x—One aberrant plant in the 1928 progeny.

THREE GENERATIONS OF TYPE A PLANTS

In addition to the foregoing tests of Type A plants, three Type A lines were carried through three generations of individual plant study. The data on this material are given in Table 4. The three original mother plants were taken at random from the 1925 Type A selections and are designated in the table as 528-P, 766-P and 786-P. A progeny consisting of twelve to fourteen plants was grown in each case and these plants were each given a progeny test the next year.

The progeny test of 528-P indicated that the mother plant approached homozygosity for spike shape and density and was heterozygous for glume shape and beak shape. The segregation in progenies 528-10 and 528-12 for spike shape may have resulted from natural crossing in F_1 or it may have been the only recognizable heterozygosity in a series of progenies each of which was slightly heterozygous but not appreciably so for the character under consideration. Spike density presents an almost similar case. Both glume shape and beak shape clearly appear heterozygous in the F_1 results and this is corroborated by the F_2 data.

Line 766 appeared in the F_1 test to be uniform for the characters studied. While there is some variation in the descriptions of the different plants there is no real indication of heterozygosity. The average character of the progeny closely approached that of the mother plant. The F_2 test also gave no real indication of heterozygosity with respect to these characters, but in four of the twelve progenies dwarf plants appeared. Obviously there was heterozygosity present with respect to the factors governing this condition. The dwarfs were of a distinct type being only a few inches high and almost completely sterile, whereas the normal plants were over a yard high and fully fertile. In progeny 766-10 one aberrant plant occurred. This had some characters unlike those of Type C or B and probably resulted from the fertilization of one floret of the mother plant by pollen of some other variety than Marquis.

The mother plant of Line 786 was almost completely intermediate in character which suggested heterozygosity. Its progeny, however, proved that it was homozygous or nearly homozygous for all four characters. The F_2 progeny tests further confirmed the homozygosity of the original mother plant. One of the fourteen progenies showed segregation which, under the circumstances, may be attributed to natural crossing.

ARTIFICIAL HYBRIDS BETWEEN TYPES C AND B

The results of the progeny tests of Type A plants definitely indicate that these plants arose from natural crossing between Types C and B. To prove or disprove this hypothesis a cross was made between representative plants of Types C and B. The F_2 plants are described for four spike and glume characters in Table 5. A brief comparison of these descriptions with those given in Tables 2, 3 and 4 reveals a striking similarity. Close scrutiny of Table 5 shows the various combinations of characters one would expect to find in F_2 . Culture 1 is B or IB for the four characters. Culture 2, on the other hand is wholly C or IC. Cultures 35, 40, 47 and 58 are I in nearly all characters. Various combinations of B or IB with C or IC are shown in,

cultures 18, 21, 25, 26, 34, 42 and 63. Character combinations similar to these appear throughout Tables 2, 3 and 4.

TABLE 5. *Descriptions of the individual F_2 progeny plants of the cross Type C X Type B for four important spike and glume characters.*

| Plant number | Spike shape | Spike density | Glume shape | Beak shape | Plant number | Spike shape | Spike density | Glume shape | Beak shape |
|--------------|-------------|----------------|-------------|------------|--------------|-------------|----------------|-------------|------------|
| 1 | IB | B | B | IB | 33 | I | I | C | IC |
| 2 | C | C | IC | IC | 34 | B | B | C | IC |
| 3 | I | IB | IB | IB | 35 | I | I | IC | I |
| 4 | I | IB | IC | I | 36 | IC | IB | C | I |
| 5 | B | B | I | B | 37 | IC | C | IC | I |
| 6 | B | B | IB | B | 38 | I | B | I | IB |
| 7 | B | B | IC | IB | 39 | IB | B | I | B |
| 8 | IC | I | I | IB | 40 | I | I | I | IC |
| 9 | B | B | I | IX | 41 | IB | B | B | B |
| 10 | B | B | IC | IB | 42 | B | IB | C | IC |
| 11 | IB | I | IC | I | 43 | B | B [†] | IB | B |
| 12 | IC | B | C | I | 44 | IB | IB | I | IB |
| 13 | C | C | I | I | 45 | IB | IB | I | I |
| 14 | C | IC | C | I | 46 | IB | B [†] | B | I |
| 15 | B | B | IB | IB | 47 | I | IC | I | I |
| 16 | IB | I | B | I | 48 | IB | IB | IC | I |
| 17 | C | I | I | I | 49 | B* | IB | B | I |
| 18 | IC | C | C | IB | 50 | IC | B | C | IB |
| 19 | B | B | IB | B | 51 | IC | I | C | I |
| 20 | IB | IC | I | IB | 52 | B* | IC | IC | I |
| 21 | B | B | C | I | 53 | I | I | IB | IB |
| 22 | I | I | IB | I | 54 | C | I | I | IB |
| 23 | I | I | IB | I | 55 | IB | IB | B | B |
| 24 | C | C [†] | C | I | 56 | B | IC | IB | I |
| 25 | IB | IB | C | IB | 57 | IB | IB | I | I |
| 26 | IB | I | C | B | 58 | I | I | IC | I |
| 27 | B | I | I | C | 59 | I | I | IB | I |
| 28 | I | I | IB | I | 60 | IC | IC | C | IC |
| 29 | IB | I | B | IB | 61 | IC | B | IB | I |
| 30 | B* | B | B | IB | 62 | IB | IB | IB | IB |
| 31 | B | B | I | B | 63 | IC | IB | IC | B |
| 32 | IB | I | C | I | 64 | I | IB | I | B |

NOTE: Transgressive segregation or out-crossing was indicated in the following cases: x=very long beak, [†]=lax spike, *=club-tipped spike, [‡]=very dense spike.

TYPE A PLANTS OF UNUSUAL APPEARANCE

Reference has been made in several of the foregoing pages to the Type A plants that did not appear from their characters to be the result of crossing between Types C and B. Examination of the cereal planting plans showed that the original Marquis 7 material and all of the selection progenies were grown more or less close to other varieties of wheat. In 1927, for example, the Type A progeny tests were adjacent to some test plots of Garnet, Reward and other well-known varieties. With our present knowledge of the frequency of natural crossing at Saskatoon it is reasonable to believe that the Type A plants of extreme character resulted from crosses of Types C and B with other varieties than Marquis.

DISCUSSION AND SUMMARY

Natural Crossing: The results of the various progeny tests and of the artificial cross between Types C and B indicate that natural crossing was

responsible for most if not all, of the Type A plants. This being the case it follows that there may occur in Marquis an amount of natural crossing considerably larger and more important than is generally recognized. Since there is no evidence that Marquis is particularly susceptible to natural crossing, and since different studies have shown large percentages of natural crossing in other varieties, it is reasonable to believe that differences in type within a variety lead to the production of various intermediates. After a few years these intermediates, some nearly homozygous, others highly heterozygous, present a motley array of forms grading from one parent type to the other and constitute no small difficulty in the improvement of the variety by selection.

The results show that because of the likeliness of natural crossing it is not advisable to grow different varieties or strains of wheat in close proximity. They indicate also that the proper time for the removal of an off-type plant is *between* its time of heading and time of flowering, for the damage from natural crossing occurs during the flowering period.

Environmental Influence: The data on fifty Type A plants and their progenies show that environmental influences did not mask inherited differences where these differences were distinct and covered at least two class values. In a few cases, plants recorded as slightly different from typical Marquis in one or more respects proved by progeny tests to be typical (Type C). But no plant recorded as distinctly different from Marquis proved to be typical. And none of the three plants recorded as typical Marquis proved to be otherwise.

There were small but distinct general differences between material grown in 1925, 1927 and 1928 which were obviously the result of seasonal conditions, and, like known systematic errors, did not greatly affect the analysis of the results. However, the particular conditions in 1928 decreased the differences in spike shape and beak shape between Types C and B and made classification more difficult. This difficulty was probably larger in Marquis than it would have been in a variety in which the shape of the spike apex is less affected by climatic conditions. Thus in the material used spike shape was an important differential character in 1925 and 1927 but not as satisfactory in 1928.

The results show that environmental effects may easily obscure small genetical similarities and differences. An illustration is afforded by the data in Table 4. There is little doubt that line 766 is reasonably uniform or homozygous for the characters studied, yet for beak shape the 1927 progeny plants fell only in classes I and IC (with one exception), whereas the 1928 progenies occurred only in classes I and IB. Apparently environment caused this difference between 1927 and 1928 results.

On the other hand, line 528 seems decidedly heterozygous yet some progenies namely cultures 4, 6, 7, 8, and 13, were recorded as uniform for all four characters. Unless these characters are controlled by the same or closely linked genetical factors, or unless the segregation in the other progenies is entirely the result of natural crossing the year before, the five progenies mentioned cannot really be as uniform as they were recorded.

The results obtained from the controlled cross between Types C and B indicate that the four characters are not governed by the same genetic factor nor does linkage play a large part in their inheritance. Furthermore natural crossing could hardly have occurred with such frequency as to bring about the observed heterozygosity of the majority of the progenies. Therefore it is apparent that small genetical similarities and differences may be masked by environmental effects.

The data in Tables 2 and 3 present cases similar to the above. It is possible and indeed probable that some of the nine lines recorded in Table 3 as non-segregating were heterozygous for minor characters in which the differences were slight. Actually such slight variation is of little practical importance whether it can or cannot be recognized. On the whole it appears that no plant can with certainty be declared a variant from its varietal type unless it is distinctly different in one particular or appreciably different in several respects.

Differential Value of Characters: The data on Type A plants, as given in Tables 2, 3 and 4 also show that the recognition of intermediacy between the two main types of Marquis 7 was a matter of reasonable certainty, for, of all the original selections designated as Type A, only four out of fifty proved to be Type C and none were Type B. The data may then be analysed to ascertain which characters most truly or accurately place a plant in the intermediate class. It is found (from Tables 2 and 4) that spike density was of little value. This is not surprising in view of the facts that Types C and B differ only twenty per cent in this character and density is moderately subject to environmental influences. Insufficient data was obtained on spike shape to indicate very definitely its value as a differential character in this material. However, Types C and B differ in spike shape chiefly in the tip form, and this character is subject to considerable fluctuation due to weather conditions. Spike shape, therefore, is of doubtful value in the recognition of Type A plants.

Both glume shape and beak shape were better differential characters. In ten cases Type A parent plants appeared to be normal Type C or B in glume shape. In only four cases did Type A parent plants appear to be typically Type C or B in beak shape. Examination of Tables 2 and 4 show further that in no case did parent plant data on spike shape or spike density indicate intermediacy where it was not already indicated by the data on either glume shape or beak shape. Furthermore, if the decision regarding the placing of a given parent plant as Type A had rested solely upon the data on beak shape, the placing of only three out of the 89 plants would have been affected. Culture 689 would have been classified as typical Type C and cultures 498 and 686 as Type B instead of as Type A, as they proved to be.

The evidence indicates that beak shape was the best character for the recognition of intermediacy in a given plant, that glume shape was nearly as valuable, and that the characters spike shape and spike density were of little assistance.

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STABILISATION DE LA MAIN-D'OEUVRE ET ORGANISATION GENERALE DE L'EXPLOITATION DE VAULUISANT (YONNE)

PREMIERE PARTIE

Etude présentée par M. M. Adolphe Javal, docteur ès sciences, et Jacques Faugeras, ingénieur agronome, au 4^e Congrès international de l'Organisation scientifique du Travail, Paris, 1929.

L'exploitation de Vuluisant, tenue pendant cinquante-cinq ans par des fermiers sans souci de l'avenir, et dont la seule préoccupation était de tirer du sol le plus grand profit immédiat possible, a été reprise en 1915 par l'un de nous. Il décida d'envisager le programme suivant :

1. Augmenter les productions à l'hectare ;
2. Diminuer la durée du travail de la main-d'oeuvre, en s'assurant un nombre constant d'ouvriers toute l'année, dont la majorité est logée en familles dans des maisons ouvrières ;
3. Réduire la fatigue de la main-d'oeuvre.

L'idée dominante fut de traiter l'exploitation comme une industrie, en essayant d'échapper le plus possible aux conditions climatiques spéciales au travail agricole.

I. AUGMENTATION DES PRODUCTIONS A L'HECTARE

A.—Par la Spécialisation des cultures.

Par exemple la pomme de terre et le lin ont toujours été éliminés, quels que fussent leur prix de vente, et dans le seul but de concentrer tous les efforts sur le plus petit nombre de produits, qui sont : betterave à sucre, blé, orge, avoine, bovidés, qui sont presque les seuls produits vendus à l'extérieur.

B.—Par l'augmentation du nombre des façons culturales.

Dans l'ensemble, on peut dire que, dans les cultures où l'on faisait 10 façons en 1920, on en fait 12 ou 14 aujourd'hui. Par exemple, un blé sur jachère se présente de la façon suivante :

1920

1. Labour de printemps (avec ou sans roulage) ;
2. Hersage ;
3. Hersage ;
4. Labour d'été (avec ou sans roulage) ;
5. Hersage ;
6. Fumure ;
7. Labour d'automne ;
8. Hersage ;
9. Semailles ;
10. Hersage.

1927

1. Labour de printemps (avec ou sans roulage) ;
2. Cultivateur canadien ;
4. Hersage ;

*M. Faugeras est à l'heure actuelle en voyage d'études au Canada et aux Etats-Unis ; il lui a été accordé une bourse d'études de la fondation Rockefeller.

5. Hersage;
6. Labour d'été (avec ou sans roulage);
7. Cultivateur canadien;
8. Hersage;
9. Fumure;
10. Labour d'automne;
11. Cultivateur canadien;
12. Hersage.
13. Semailles;
14. Hersage.

Ce nouveau régime a été instauré grâce aux dispositions suivantes:

1. En utilisant des tracteurs, qui sont attelés aux cultivateurs canadiens (en avril pour préparation de blé sur jachère et sur betterave) et aux pulvérisateurs (en avril pour préparation de blé sur jachère et sur betterave) et aux pulvérisateurs (en avril pour préparation de betterave);

2. En occupant 5 charretiers exclusivement aux travaux aratoires;

3. En réservant les travaux spéciaux aux professionnels qui sont cités plus loin au tableau d'organisation et en réservant les travaux dits saisonniers à une équipe de 8 hommes occupés de la façon suivante;

| | | |
|---------------------------------------------------------|-------------------|-------------|
| 1. Battage des céréales..... | 1 sept.—1 juin | à l'heure |
| 2. Coupe de bois et façonnage..... | 1 sept.—1 mai | au stère |
| 3. Binage des betteraves à sucre (deux façons) | 15 mai —15 juill. | à l'hectare |
| 4. Relevage des gerbes..... | 15 juill—15 août | à l'hectare |
| 5. Arrachage des betteraves à sucre..... | 1 oct. — 1 déc. | à l'hectare |
| 6. Chargement des betteraves..... | 1 oct. — 1 déc. | à la tonne |
| 7. Drainage et entretien des chemins..... | 1 déc. — 1 avril | à l'heure |

4. En augmentant le troupeau ovin et bovin pour obtenir une plus grande quantité de fumier. Les résultats de ce régime sont indiqués dans le tableau suivant, qui montre les variations de la production des céréales rapportées à l'hectare:

| | |
|------------|----|
| 1920 | 10 |
| 1921 | 16 |
| 1922 | 16 |
| 1923 | 13 |
| 1924 | 12 |
| 1925 | 16 |
| 1926 | 17 |
| 1927 | 19 |

II. DIMINUTION DE LA DUREE DE TRAVAIL DE LA MAIN-D'OEUVRE

C'est là le point capital de l'affaire, qui se manifeste par un règlement de travail appliqué dans ses grandes lignes dès 1919, et strictement depuis 1924, date à laquelle il a été imprimé et distribué à tous les nouveaux ouvriers. Voici les principaux passages de ce règlement de travail.

Journées de Travail—En juin, juillet et août, elles sont de dix heures et demie; en novembre, décembre, janvier, de neuf heures et demie. Pendant

les six autres mois, elles sont de dix heures. Quand la journée est de dix heures, on travaille cinq heures avant midi et cinq heures après midi. Le repos est de deux heures en été, et de une heure et demie en hiver pour le déjeuner. Quand la journée est de dix heures et demie, la demi-heure supplémentaire se fait le matin; quand elle est de neuf heures et demie, la demi-heure supprimée tombe le soir. Les attelées doivent se faire sans interruption, sans casse-croûte. Les ouvriers doivent être présents aux quatre coups de cloche qui annoncent le commencement et la fin des attelées et régler leur montre sur l'horloge de la cour.

Jours Fériés—Avec les dimanches, ils sont 61: restent donc 304 jours de travail.

Paye—La paye se fait par mois, à partir du 5 de chaque mois, pour le mois précédent. A titre exceptionnel, il est donné des acomptes le samedi soir après la journée de travail dans le courant du mois. Toutes les absences du personnel sont, sans exception, déduites des salaires. Le calcul des déductions, comme celui des heures supplémentaires, est fait sur la base de vingt-cinq jours de travail en moyenne par mois, et de dix heures de travail en moyenne par jour, même pendant les périodes où la journée est de 9 heures et demie ou de dix heures et demie.

Démissions et congés.—Les démissions et congés doivent être donnés à un mois de préavis, de part et d'autre, pour les ménages logés en famille dans leurs meubles, dans les maisons ouvrières du Domaine; à huit jours de préavis pour les ouvriers au mois nourris et logés en célibataires (s'il y en a) et sans préavis pour ceux qui, non logés et non nourris, viennent des communes voisines et sont embauchés à l'heure. L'embauchage à la journée n'existe pas.

Les départs en dehors des conditions régulières donnent lieu à des retenues de salaires. Les ouvriers logés dans les maisons ouvrières du Domaine et qui partent abandonnent leur jardin en même temps que leur logement. Ils ne peuvent emporter que les légumes et fruits à maturité et ne peuvent vendre ni légumes en terre, ni fumier. Le logement gratuit faisant partie du contrat de travail et étant attaché à la fonction spéciale de l'ouvrier (vacher, berger, électricien, jardinier, garde) doit être abandonné le jour même de la cessation du travail, pour être mis à la disposition du successeur à la fonction.

Le Domaine fournit aux ménages de ses maisons ouvrières, à prix fixe toute l'année, différentes denrées alimentaires, chaque samedi. Rien n'est payé comptant; tout est déduit sur la paie de fin de mois.

Organisation du Travail—Les ouvriers agricoles logés en famille dans les maisons ouvrières ne viennent pas le dimanche et les jours de fête. Cependant le berger et le vacher doivent assurer leur service les jours de repos. Les célibataires doivent à tour de rôle prendre la garde le dimanche et soigner les chevaux. Il est attribué à ce service une rémunération spéciale. A condition de s'entendre, ils peuvent permuer entre eux à leur convenance.

Déroations.—Il sera fait à ce règlement des dérogations si elles sont nécessaires pour assurer la bonne marche de l'exploitation. En cas de mauvais temps persistant ou d'accident quelconque aux machines ou animaux,

il peut être ordonné des heures ou des demi-dimanches supplémentaires et payés que personne n'a le droit de refuser. Les ouvriers ne doivent pas perdre de vue qu'aucun règlement n'est opposable aux mesures nécessaires pour la sauvegarde des récoltes, du bétail et de leurs outils de travail.

Ce règlement est applicable à tout le personnel de l'exploitation, c'est-à-dire aux travailleurs indiqués dans le Tableau d'organisation, qui se réfère principalement à la fonction technique, car les cinq autres fonctions fayolien-nes sont assurées par les deux dirigeants: chef d'exploitation et régisseur.

PLAN D'ORGANISATION :

Chef d'exploitation (travaux de cœur), donnant ses ordres sur place ou les transmettant par téléphone lorsqu'il est absent :

- Un mécanicien ;
- Un chauffeur ;
- Un électricien ;
- Un charron-charpentier ;
- Un maréchal-forgeron ;
- Un maçon-couvreur ;
- Un peintre-nettoyeur sanitaire ;
- Un jardinier.

Régisseur (travaux des champs) :

- Une téléphoniste-comptable (femme du régisseur) ;
- Un stagiaire chef d'équipe :

Cinq charretiers ;

Huit hommes de cour en équipe mobile ;

- Un vacher et sa femme ;
- Un berger et un aide ;
- Un palefrenier homme de cour ;
- Une bonne.

Soit 2 dirigeants, 8 hommes dans les ateliers, 21 hommes aux travaux des champs, ce qui fait un total de 29 salariés.

III. REDUCTION DE LA FATIGUE DE LA MAIN-D'OEUVRE

Elle a été réalisée par l'aménagement, à proximité de la ferme, de maisons ouvrières, qui évitent les déplacements avant et après le travail ; par l'emploi de moteurs électriques pour les tâches les plus simples (V. au paragraphe des moteurs) ; par l'emploi de systèmes divers ; silo, élévateur, wagonnets pour les aliments du bétail, etc.

(à suivre)

CONCERNING THE C.S.T.A.

STATEMENT BY THE CHAIRMAN OF THE COMMITTEE ON EDUCATIONAL POLICIES

The Chairman, Dr. L. S. Klinck, did not present a formal report on the work of the Committee during the past year. The statement which he made was a personal one, and was based largely on studies which had been made in his own local under the direction of Mr. E. E. Cairncross and Mr. H. R. Hare. The constructive interpretation which these men placed on the data collected, indicated clearly that their insight into the problem was the result of close observation, based on years of experience as extension workers.

Such men, in the opinion of the Chairman, were the only ones who could get at the heart of the matter; and he expressed his satisfaction that the Committee on Nominations had decided to confine its nominations for membership on the Committee on Educational Policies to men who have a direct interest in, and an intimate personal knowledge of, the problems of the field man. He felt this was very important, more especially since the Society had not previously encouraged the consideration of matters which affected directly the immediate interests of this important section of its membership.

Dr. Klinck strongly supported the suggestion that the locals make the study of the function and the status of district representatives and of other agricultural officials who are engaged in closely related work, a major topic for discussion during the coming winter. The importance of the question and the number of members directly affected, should ensure spirited discussions, should increase interest in the local organizations and result in the fullest and frankest expression of opinion. With the information which these discussions would provide, the Committee should be prepared to make a progress report next year and, after further study by the locals, to submit findings of real value to the Convention in 1932.

The Chairman expressed his great appreciation of the attitude of hundreds of members of the Society who have continued to stand by the organization with the utmost loyalty, even though they felt, at times, that their own particular problems were not receiving the attention which they deserved. In this connection, he stated that the principal reason the results obtained by research men had been published in *Scientific Agriculture* to the almost total exclusion of other subject matter, was because these workers had submitted the results of their researches in a form approved by scientists; whereas, as yet, not even a beginning had been made in the application of the scientific method to those problems which particularly interest extension men. He was confident that if the field workers would follow the example set by the investigators in this regard, their special interests would receive like recognition. The inclusion of scholarly articles—historical, philosophical or educational, as well as scientific—in relation to agriculture, would broaden the scope of the official organ and improve the status of the entire membership.

In conclusion, the Chairman pointed out that it was now proposed to give to the extension men as full opportunity to discuss their problems as instructors and investigators had always enjoyed. The initiative, they were reminded, rested with themselves. If they embraced the opportunities presented, the next two years should not be lacking in interest to any member of the organization.

NOTES AND NEWS

M. B. Davis (McGill '12) Chief Assistant, Division of Horticulture, Central Experimental Farm, Ottawa, has returned from a year of research work in England. At the Research Station at Long Ashton he worked in nutritional problems of fruit trees and made a study of cider and other fruit by-products. At Malling his time was spent principally in rootstock work. At the conclusion of the year's work Mr. Davis was awarded the degree of M.Sc. by the University of Bristol.

The annual joint basket picnic of the Niagara Peninsula local and the Western Ontario local was held at the Ontario Horticultural Experimental Station, Vineland Station, July 19th, and was a very successful affair.

C. E. Benoit (Montreal '24) has resigned his position as poultry inspector with the Dominion Live Stock Branch at Ottawa and joined the Jamesway Limited of Weston, Ont. His present address is Box 323 Montmagny, P.Q.

Manley Champlin (S. Dakota '09) Senior Professor of Field Husbandry, University of Saskatchewan, Saskatoon, and family left recently for Berkeley, California, where Prof. Champlin will spend a year in special work at the University of California.

Dr. W. Allen (Saskatchewan '22) Professor of Farm Management, University of Saskatchewan, Saskatoon, will give a paper on "Types of Farming in Canada" at the International Conference of Agricultural Economists, being held at Cornell, August 18-29. He will also give a radio address upon the same subject.

Several members of the Macdonald College Staff are spending the summer in England attending various congresses. Professor J. G. Coulson is attending the Botanical Congress, Dr. R. L. Conklin the Veterinary Congress and Professor W. A. Maw the Poultry Congress. Dr. E. M. Duporte is visiting the Empire Marketing Board in connection with problems in Parasitology. Mr. G. M. Tait has resigned his position as Lecturer in the Horticultural Department at Macdonald College, and is at present Graduate Assistant in Vegetable Gardening at Cornell University. His address is 209 College Avenue, Ithaca, New York.

Gustave Geizler (N. Dakota '28) formerly with the North American Life Assurance Co., Saskatoon, has accepted a research position at the State College Station, Fargo, N. Dakota.

Prof. A. H. Joel (Michigan '19) has returned to his duties as head of the Soils Department, University of Saskatchewan after an extended trip in the United States.

The following changes have recently taken place in the Agricultural Representative Service of the Ontario Department of Agriculture:

Grenville—H. L. Trueman (Toronto '21) has resigned and accepted the position of General Secretary of the C.S.T.A., and is succeeded by A. M. Barr, a graduate of Toronto 1930. Mr. Barr has been Assistant Representative in Huron County since June.

Halton—A. P. MacVannel, who spent 21 years as an Agricultural Representative has resigned to accept a position in the Records Branch in the Federal Live Stock Branch, Federal Department of Agriculture, Ottawa. He is succeeded by A. G. Kirstine, who graduated from Toronto in 1925. Mr. Kirstine has been Assistant Representative in York County since last November.

Durham—J. Y. Kellough has resigned to become sales representative for their coarse grains in Ontario for the Canadian Co-operative Wheat Producers Limited with headquarters at Toronto. He is succeeded by E. A. Summers who graduated from the O. A. C. in the year 1925. Mr. Summers has been Assistant in Oxford County since last September.

Temiskaming—Mr. W. G. Nixon has been appointed Superintendent of the Demonstration Farm and has relinquished the position of Agricultural Representative. He is succeeded by Mr. E. F. Cook, who has been Assistant Representative in Middlesex County since September last. Mr. Cook spent seven years as a Representative in the District of Kenora.

S. G. Thomson (Alberta '29) has changed his address to 3014 McCallum Avenue, Regina, Sask.

W. C. Hopper (Toronto '20) has obtained leave of absence from the Central Experimental Farm, Ottawa, to continue graduate work in the Department of Economics, Cornell University.

The Eastern Ontario local expect to start bowling around October 9th, and have secured Karry's Alleys for the purpose. Intimations from members would indicate that bowling will be more popular than ever this year.

H. T. Robertson (Saskatchewan '28) has changed his address to 1015 5th Ave. W., Calgary, Alberta.

R. D. Sinclair (Alberta '18) Professor of Animal Husbandry, University of Alberta, and winner of the T. Eaton overseas scholarship for 1930, writes that he is comfortably established at the Rowett Research Institute and has received a warm welcome. His address is in care of the above institute, Bucksburn, Aberdeen, Scotland.

H. J. Siemons (Manitoba '25) of Brandon, and A. R. Judson (Manitoba '16) of Dauphin, are zone managers for the Colonization Finance Corporation of Canada Ltd., with headquarters at 460 Main St., Winnipeg, Man.

C.S.T.A. LOSES ASSISTANT SECRETARY

Members of the C.S.T.A. will regret to learn that Miss Helen Henry, Assistant Secretary, has severed her connection with the Society. Her knowledge of the office detail and her editorial ability have been greatly appreciated by those who have known her. During the illness of the late general secretary and following his death her services were invaluable. At this time Miss Henry carried an exceedingly heavy load culminating in the very successful convention in the Maritime Provinces. Following this she spent some time in acquainting the new general secretary with his duties. During the three months previous to her resignation she also coached her successor, Miss Margaret Dewan.

While Miss Henry has officially left the C.S.T.A., she retains her keen interest in its development and her services are still available on occasions when needed. In accepting her new position as Assistant Secretary of the Canadian Seed Growers' Association, she goes to an organization closely allied to the C.S.T.A. and strengthens the bonds of friendship and coöperation which have always existed between these two bodies. During her years of service here Miss Henry has helped the Society through many difficult periods and has made a host of friends who know her worth. We congratulate the Seed Growers in securing her in the face of keen competition from several other organizations, and we wish Miss Henry the best of success and happiness in her chosen field.

WORLD'S GRAIN EXHIBITION AND CONFERENCE

Wholehearted practical support should be given by all public bodies of Canada to the World's Grain Exhibition and Conference to be held at Regina in 1932 in the opinion of L. H. Newman, Dominion Cerealists, Federal Department of Agriculture, in the course of an address a few days ago to the members of the Regina Rotary Club.

Every public body should give support to the undertaking because of the effects which would follow the holding of this, the first world-wide grain Exhibition and Conference in the history of agriculture.

The effects of the exhibition Mr. Newman summarized as follows:—

1. It will advertise Canada to the world at large to a greater extent than any other event.
2. It will give Canada the opportunity to "take stock" and ascertain her standing among other countries of the world in agricultural matters.
3. It will stimulate Canadian growers in the use of the best varieties of seed and in the adoption of best cultural methods.
4. It will clear away certain misconceptions in the minds of some English buyers with regard to the composition of Canadian grain.
5. It will give Canadian farmers a greater appreciation of some of the difficulties faced by British millers in the handling of Canadian grains.
6. It will bring nearer home to the Canadian farmer the kind of competition he has to meet in the open markets of the world.

"The 1932 World's Grain Exhibition and Conference will be unique" said Mr. Newman "in that it will be held in the latter part of July and first part of August and that the exhibits will have to be produced in 1930 or 1931 giving us the opportunity to conduct growing tests to determine the degree of purity possessed by them. It will put a premium on well bred seed and will show to the world that Canada appreciates the value of good seed and remove possibility of awarding these large cash prizes to people who show samples which, while excellent in appearance, are contaminated to a considerable extent. The growing tests will demonstrate the desirability of uniformity as to breeding and trueness to type."

Mr. Newman made special reference to the Garnet variety of wheat which he stated while not so popular with the English miller as some other varieties on account of the colour of the flour nevertheless had some peculiar characteristics which made it of interest to the millers. Last summer, Mr. Newman stated he had the opportunity of conducting large scale experiments with thousands of bushels of this variety both in England and on the continent and the millers are impressed with the Garnet wheat.

"The people of the Old Country and of the Continent are greatly interested in the 1932 grain Exhibition and Conference" he said. "They feel we must get together to a greater extent than we have in the past. They consider it foolish that people who produce a large commodity like wheat should keep apart as we have been doing from those who buy that particular commodity". Mr. Newman also made reference to the agricultural conference called in 1929 by Premier Mussolini of Italy and the opportunity there given for discussing the value of the 1932 Exhibition and Conference. Representatives from 35 different countries met at that time" said Mr. Newman "and they were clearly interested in the opportunities opened to them by the 1932 exhibition to be held at Regina. It will be a wonderful thing to get these people together from all these different countries to show them some of the things which are being done."

Another important feature of the 1932 exhibition as he saw it, he stated, would be the opportunity of getting English and European millers together to learn that some of their fears regarding the character of Canadian wheat are not well founded. "There has been a disposition to believe that our wheat is becoming more or less mixed, too many varieties being grown and that these mixtures must affect the general quality of our product. That is not the case. True, there are many varieties of wheat but the number is being gradually reduced to those best suited for different zones and up to the present I have not found any definite evidence so far as mixture of varieties is concerned that our wheat has suffered any deterioration. Many thousands of samples of Canadian wheats coming to Liverpool markets have been investigated by growing tests at Ottawa and the fears which exist are not well founded."